Bulletin No. 101 1921

Agricultural Research Institute, Pusa

Some Insects recently noted as Injurious in South India

BY

T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S.,
Acting Government Entomologist, Madras

(Reprinted from the Proceedings of the Third Entomological Meeting.)

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1921
Price As. 8.

Sylepta lunalis was found in numbers on grape in November 1917 in Coimbatore. Pupa inside leaf fold.

The *Ragi* ear-head worm. This is a slender elongated caterpillar found on the ripening ear-heads of the *ragi* plant. Sometimes appreciable damage is done to the ears.

The Saturniad moth, *Actias selene*, has been noted as a regular pest defoliating *Odina wodier* trees in Coimbatore for the past two or three years. (See my note in the *Bombay Journal*, XXIII, p. 792).

The following are already known pests among Lepidoptera; but I have added some extra information regarding their status.

Diacrisia obliqua. This Arctiad has not been recorded till now from South India. It is found on sweet-potato and *Lantana* in Malabar. On the Wynaad Hills I found it on a variety of other plants.

Orgyia postica is found to be a pretty bad pest of castor in Coimbatore. A coloured plate of its stages is herewith exhibited. (Plate 17.)

Euproctis fraterna has been noted on rose, doing serious damage in South Malabar. It is also found on pomegranate. A coloured plate is exhibited herewith.

Prodenia litura. Noted bad on *Colocasia* in Tanjore and was recently noted on onions in Coimbatore.

Dichocrocis punctiferalis on arrow-root plant in North Malabar.

Hyblœa puera is often serious on *Millingtonia* and *Bignonia*.

Laphygma exigua has been noted on coriander at Coimbatore.

Diptera.

Pachydiplosis oryzæ. This is noted as a very important and serious pest, chiefly in the Northern Circars, Tanjore and Ramnad districts. The fly is found breeding on other Gramineæ also. It is known as *Anaikombu* in Tamil districts.

Bitter-gourd gall-fly, (Pl. 18). The distal tender shoots of the bitter-gourd plant often develop a long gall and the growth of the plant is much affected by the maggot found inside the gall.

The *Cumbu* fly. This is also a Cecidomyiad noted on *cumbu* in Coimbatore.

An Anthomyiad has been noted on tomato also.

Among fruit-flies we have a few species of *Bactrocera*, *Chætodacus*, etc., affecting mangoes, guavas, etc. :—

Chætodacus ferrugineus incisus, on guava, Bangalore.

Bactrocera caudata. On snake-gourd, Coimbatore.

Dacus brevistylus, on water-melon, Cuddapah.

Dacus longistylus, on *Calotropis*.

Carpomyia vesuviana, Coimbatore, on *ber* fruit.

Parasites and predators

The following parasites and predators of the pest were observed :—

1. *Tropideucoila* sp. (probably a new species of the family Cynipidæ). The adults of the parasite were found in small numbers in the field between the end of March and the second week of April. Also a few specimens emerged from the rearing cages in the laboratory. The parasite did not seem to appreciably reduce the population of the pest.

2. *Ormyrus* sp. (Fam. Torymidæ). The chalcidoid wasp was very common in the field and emerged in large numbers in the rearing cages in the laboratory during the second and third weeks of April when the pest was in the second generation. On account of parasitization by this species a significant reduction in the population of the pest was observed in the field and the attack decreased markedly as would be found in the statement of incidence of the pest in the appendix. In association with this parasite, the species *Stenomalus muscarum* (Linn.) (Pteromalidæ) and *Eurytoma* sp. were also found, but the precise role played by them has not been determined. About the same time, the neuropterous predator, *Chrysopa virgestes* was also quite common in the field and its nymphs were found devouring the pest maggots. In the third generation of the pest, extending from the last week of April up to the second week of May, the chalcidoid parasites and the predator were found occurring in very small numbers and the higher incidence of the pest at this time was probably due to this.

Summary

1. *Acanthiophilus helianthi* (Trypetidæ) has been noticed for the first time as a serious pest attacking safflower in India. This is also the first record of this genus and species from this country.

2. The pest was active from March to May and caused serious damage to both early and late sown varieties of safflower, in some of which the infestation of floral buds, was as high as 90 per cent.

3. The fly punctures the flower bud and lays eggs on the inner side of its involucre. The maggots feed upon the florets and even bore into the thalamus. The florets are thus partially or completely destroyed, with the result that the bud does not open. Pupation takes place generally in the bud. The flies emerge through small holes on the surface of the bud. The duration of various stages in April in the laboratory with average maximum and minimum temperatures of 85·2°F. and 78·5°F. was : egg, 25 hours, maggot and pupa, each seven days and adult, 10 days. The fly has three generations during the season (March-May).

4. Two species of hymenopterous parasites on the immature stages of the pest are recordded.

Acknowledgements

The authors are indebted to Mr. H. K. Munro, Entomologist, Department of Agriculture, Union of S. Africa, Pretoria, for the identification of the species and for information about its distribution and host plants outside

India. We are also thankful to the Imperial Economic Botanist for the facilities provided for examining his experimental crop of safflower for the study of the pest. To Mr. Deshpande, M.Sc. (Ag.), Special Research Assistant of the Botanical Section, we are obliged fors upplying some particulars of the varieties.

REFERENCES

Bhatia, H. L. and Singh, M. (1939). *Ind. J. Ent*, **1**, 110-11

Efflatoun, H. C. (1924). *Mem. Soc. Roy. Ent. Egypt* **2**, 117

Meigen, J. W. (1826). *Systematische Beschreibung europaischen Zweiflg üligen Insekten*, **5**, 344

Ram, R. (1917). *Proc. Ent. Mtg. Pusa* **2**, 97

Rondani, C. (1871). *Dipterologiae Italicae Prodromi* **7**, 12

Rossi, P. (179). *Fauna Etrusca* **2**, Liburni

Seguy, E. (1930). *Mem. Soc. Sci. Nat. Marocco* **24**, 177.

APPENDIX

Statement of the incidence of the fruit fly on various varieties of safflower at Delhi from 28th March to 15th May 1939

Serial No. and features of the type	Number of observations	Total No. of flower buds examined	Average percentage of attack	Range of incidence and remarks
1. (S. L.)	17	449	14·7	5—40 per cent; attack increased after the third week of April.
2. (S. L.)	17	500	12·4	5—45 per cent; attack increased after the third week of April.
3. (S. E.)	17	415	16·6	5—45 per cent; attack increased after the third week of April.
4. (S. E.)	17	478	14·6	5—35 per cent; attack increased after the third week of April.
5. (S. L.)	15	431	16·9	5—45 per cent; attack increased after the third week of April.
6. (S. L.)	15	471	14·8	5—45 per cent; attack increased after the third week of April.

S = Big spines

L = Late variety

E = Early variety

APPENDIX—*contd.*

Serial No. and features of the type	Number of observations.	Total No. of flower buds examined	Average percentage of attack	Range of incidence and remarks
7. (S. L.)	15	437	16·4	5—50 per cent; attack increased after the third week of April.
8. (s. L.)	16	464	15·5	10—45 per cent; attack high up to the first week and after the third week of April.
9. (s. L.)	16	555	10·5	5—50 per cent; attack increased after the third week of April.
10. (s. L.)	16	471	10·3	5—35 per cent; attack increased after the third week of April.
11. (s. L. F.)	16	376	50·0	10—70 per cent; attack high up to the first week and after the third week of April.
12. (s. L. F.)	16	445	31·2	10—70 per cent; attack high up to the first week and after the third week of April.
13. (s. L. F.)	16	569	19·5	10—65 per cent; attack high up to the first week and after the third week of April.
14. (s. L. F.)	16	424	16·4	5—45 per cent; attack high up to the end of March and after the third week of April.
15. (s. L. F.)	16	490	15·7	5—55 per cent; attack high up to the first week and after the third week of April.
16. (s. L. F.)	16	417	21·1	5—60 per cent; attack increased after the third week of April.
17. (s. L. F.)	16	497	13·8	5—65 per cent; attack increased after the third week of April.
18. (s. L.)	15	319	17·8	5—45 per cent; attack increased after the third week of April.

S = Big spines
s = Small spines
L = Late variety
F = Felted variety

APPENDIX—*contd.*

Serial No. and features of the type	Number of observations	Total No. of flower buds examined	Average percentage of attack	Range of incidence and remarks
19. (s. L.)	15	332	14·7	5—40 per cent; attack increased after the third week of April.
20. (s. L.)	15	360	31·3	5—65 per cent; attack high up to the first and after the second week of April.
21. (s. L.)	15	349	35·5	25—55 per cent; attack high throughout but more so after the third week of April.
22. (s. L.)	15	341	30·7	10—60 per cent; attack high up to the first week and after the third week of April.
23. (s. L.)	15	357	18·2	5—45 per cent; attack increased after the third week of April.
24. (s. L.)	15	332	11·4	5—30 per cent; attack increased after the third week of April.
25. (s. L.)	15	366	17·4	5—40 per cent; attack increased after the third week of April.
26. (S. E.)	15	312	20·8	5—50 per cent; attack increased after the third week of April.

S —Big spines
s —Small spines
L—Late variety
E—Early variety

APPENDIX—*concld.*

Serial No. and features of the type	Number of observations	Total No. of flower buds examined	Average percentage of attack	Range of incidence and remarks
27. (S. E.)	15	338	20·1	5—50 per cent; attack increased after the third week of April.
28. (S. E.)	15	378	13·7	5—60 per cent; attack increased after the third week of April.
29. (s. E.)	15	318	30·1	5—60 per cent; attack increased after the third week of April.
30. (s. L.)	15	347	61·9	30—95 per cent; attack high throughout but more in the beginning and towards the end of the season.
31. (s. E.)	14	350	26·8	10—55 per cent; attack increased after the third week of April.
32. (s. E.)	14	329	31·0	10—60 per cent; attack increased after the third week of April.
33. (s. E.)	14	335	31·6	5—75 per cent; attack increased after the third week of April.
34. (s. E.)	14	359	54·5	40—85 per cent; attack high, more in the beginning and towards the end of the season.

S—Big spines
s—Small spines
L—Late variety
E—Early variety

GIPD—3 S—540 IC of AR—19-6-40—89.

THE IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH

Parasites of the Insect Pests of Sugarcane in the Punjab

BY

KHAN A. RAHMAN

Reprinted from

The Indian Journal of Agricultural Science

Vol. XI, Part I, February 1941

PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI.
PRINTED BY THE MANAGER, GOVERNMENT OF INDIA PRESS, NEW DELHI,
1941.

PARASITES OF THE INSECT PESTS OF SUGARCANE IN THE PUNJAB

BY

KHAN A. RAHMAN, B.Sc. (EDIN.), PH.D. (CANTAB.), F.R.E.S.

Entomologist, Punjab Agricultural College, Lyallpur

(Received for publication on 30 June 1940)

I. INTRODUCTION

SUGARCANE in the Punjab is attacked by a number of insect pests, the most important of which are the Pyralid moths, *Scirpophaga nivella* Fab., *Argyria sticticraspis* Hampsn., and *Chilo trypetes* Bisset and the Fulgorid bug, *Pyrilla perpusilla* Wlk. Between them they destroy about 35 per cent of the crop annually, but in a year of heavy outbreak each may be responsible for destroying 67 per cent of the crop. These pests are attacked by a number of insect parasites, observations on which were taken up as early as 1921 [Husain, 1921-1938]. Since 1934 these parasites have been under closer and more intensive study at four different centres in the Punjab, viz. Sonepat, Gurdaspur, Jullundur and Lyallpur, each centre being representative of the soil and climatic conditions under which sugarcane is grown in the Punjab. The data collected during the course of these investigations is presented in this article.

II. SPECIES OF PARASITES

ORDER HYMENOPTERA

1. Family Scelionidae

Teleonomus (*Phanurus*) *beneficiens* Zehnt.

Distribution.—This parasite is widely distributed in the Punjab.

Insect hosts.—It parasitizes the eggs of *Scirpophaga nivella* Fab. So far, it has not been found on the eggs of any other insect host in the Punjab.

Bionomics.—The female parasite inserts her ovipositor, through the hairy covering of the egg-cluster, into an egg of the host insect and lays an egg therein. In captivity, a female parasite laid a total of 20 eggs in different egg-clusters of the host insect. The parasitized egg always turns black in colour. Table I gives the percentage of parasitization of *Scirpophaga nivella* Fab. eggs during February-October at Jullundur.

It is seen from Table I that *T. beneficiens* Zehnt. is most active in April and in August-October when it completes its life-cycle in 10-12 days. During May-July, when the temperature in shade is 117°F. and humidity 14 per cent, it becomes scarce. Its activities during November-January, when the insect host is present only as a hibernating caterpillar, have not been ascertained so far.

TABLE I

Percentage of parasitization of S. nivella *Fab. eggs by* T. beneficiens *Zehnt. at Jullundur*

Month	Number of host eggs examined	Number of host eggs found parasitized	Percentage parasitization
February .	830	148	17·8
March .	961	181	19·9
April .	339	173	51·0
May .	1,385	24	1·7
June .	439	*Nil*	*Nil*
July .	1,606	53	3·3
August .	1,821	848	46·6
September	27	14	52·0
October .	1,401	961	68·6

2. Family Chalcididae

Trichogramma 2 spp.

Distribution.—These parasites are common throughout the Punjab.

Insect hosts.—Two species of *Trichogramma* (not yet specifically identified) have been bred out in the Punjab from the eggs of *Argyria sticticraspis* Hampsn., *Chilo zonellus* Swinh., *Sesamia uniformis* Dudgn., and *Emmalocera depresella* Swinh.

Bionomics.—*Trichogramma* spp. are active during March-October. The period of their greatest abundance, however, is September-October, when in certain years they may parasitize 90 per cent of the host eggs. One of these two species of *Trichogramma* completes its life-cycle in the eggs of *Argyria* in about six days at 90°-98°F.

Elasmus zehntneri Ferr.

Distribution.—This parasite has so far been reported from Jullundur, Lyallpur and Sonepat.

Insect host.—It parasitizes only the full-grown larvae of *Scirpophaga nivella* Fab.

Bionomics.—*E. zehntneri* Ferr. is most active during July-February. The female selects a mature caterpillar for oviposition, stings it into a state of torpidity and lays its eggs in a cluster besides it. On hatching, the parasite larvae feed on the body juices of the paralysed host caterpillar, and when full-fed, they pupate in the tunnel (in which the host caterpillar was feeding in the stem of sugarcane) without cocoons.

Rhaconotus scirpophagae Wilksn.

Distribution.—This parasite is common at Lyallpur, but rare at Jullundur and Sonepat.

Insect hosts.—It attacks the larvae of *Scirpophaga nivella* Fab., *Emmalocera depresella* Swinh. and *Chilo trypetes* Bisset.

Bionomics.—It is active during October-March when it parasitizes 1-2 per cent of the hibernating host larvae, particularly those of *Scirpophaga nivella* Fab.

Goryphus sp.

Distribution.—This parasite is common at Jullundur, Lyallpur and Sonepat and rare at Gurdaspur.

Insect hosts.—It attacks the larvae of *Scirpophaga nivella* Feb. and *Chilo trypetes* Bisset.

Bionomics.—It is active during July-February : in 1934-35 and 1935-36 it parasitized respectively 13 and 3·2 per cent of the larvae of *Scirpophaga* during this period at Jullundur.

Stenobracon (*Glyptomorpha*) *desae* Cam.

Distribution.—It is common at Lyallpur and Sonepat but rare at Jullundur. It has also been recorded at Jhelum.

Insect hosts.—It parasitizes the larvae of *Scirpophaga nivella* Fab., *Argyria sticticraspis* Hampsn., *Chilo trypetes* Bisset, *Emmalocera depresella* Swinh. and *Chilo zonellus*, and the pupae of *Scirpophaga nivella* Fab.

Bionomics.—It is active from July to September.

Harmoniae sp.

Distribution.—It is common at Gurdaspur and Lyallpur but rare at Jullundur.

Insect hosts.—It parasitizes the larvae of *Scirpophaga nivella* Fab. and *Schaenobius bipunctifer* Wlk. (Rice borer : Pyralidae : Lepidoptera).

Bionomics.—It is active from September to February.

Chelonus sp.

Distribution.—This parasite has so far been collected from Sargodha only.

Insect hosts.—It parasitizes the larvae of *Scirpophaga nivella* F. and *Emmalocera depresella* Swinh.

Bionomics.—It was collected from the larvae of *Scripophaga* in October and from those of *Emmalocera* in April.

3. Family Encyrtidae

Ooencyrtus papilionus Ashm.

Distribution.—This parasite is uniformly distributed in the Punjab.

Insect host.—It is a very important egg parasite of *Pyrilla perpusilla* Wlk.

Bionomics.—The parasite is scarce during April-June. It becomes active in July, but it reaches its peak during the period from September to December when, along with *Tetrastichus pyrillae* Craw., it may parasitize 79 per cent, with an average of 30 to 40 per cent, of *Pyrilla* eggs. There is considerable reduction in its numbers during January-March, when it is found in sugarcane trash.

Teak leaf-gall. Throughout the West Coast, teak leaves are found covered with numerous gall-like formations with hairy out-growths on the lower surface. I believe the galls are caused most probably by a gall-fly ; I even got bright pink-coloured maggots crawling out of these but have not succeeded in rearing out the adults. Mr. Stebbing in his book on Indian Forest Insects, p. 120, thinks that the gall is due to a Cucujid beetle, *Silvanus advena*. This has to be verified.

RHYNCHOTA.

Two or three species or *Coptosoma* have been noted as swarming on different plants in South India. These are—

Coptosoma naziræ (Plate 10, figure *l*). On most vegetables such as cluster-beans, *Hibiscus*, etc., and mango shoots.

Coptosoma ostensum, Dist., a minute light-yellowish-green species found by the thousand on young shoots and leaves of *Butea frondosa* in the forest around Coimbatore in December.

The black oval shining Pentatomid, *Brachyplatys vahlii*, is often found in numbers in company with the common *Coptosoma cribraria* on *agathi* (*Sesbania*).

Vitellus orientalis (Plate 10, figure *i*) is a large greenish Pentatomid with sharp prothoracic spines which has been noted as puncturing orange fruits in Kurnul. The effect of the puncturing appears to hasten rotting and also attraction for fungi. It has to be verified whether the real injury is done by these or fruit-sucking Noctuids of the genus *Ophideres*.

The Lygæid bug, *Nysius inconspicuus*, is often found bad on growing gingelly in South Kanara during the months of February-April.

Helopeltis (*theivora**) on tea in Pirmaad and Travancore, and *Megacœlum stramineum*, found in company with *Calocoris angustatus* (see *Year Book Madras Department*, 1917, p. 83, for a paper by Mr. Ballard), are the Capsids of importance.

Purohita sp. (Pl. 19, fig. 1). A pale-greyish bug found in some numbers at the stem of growing bamboo, especially between the stem and the sheaths. The mealy mass of eggs is very commonly found in that place also ; Coimbatore.

Curry Leaf-hopper. A minute active Fulgorid found in numbers doing appreciable damage to the curry-leaf plant, *Murraya koenigi*, in Coimbatore and Malabar.

Clovia lineaticollis (Plate 10, figure *m*). Common on jak shoots and tender leaves all over Malabar. Due to the attack the leaves curl up ; often inside these curls nymphs enclosed in frothy matter are also found.

* *Helopeltis antonii* is perhaps intended. [*Editor.*]

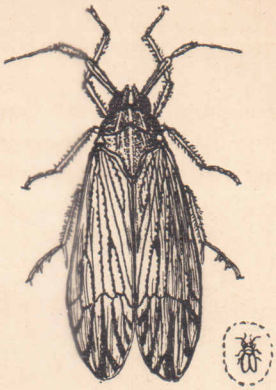


Fig. 1.—*Purohita* sp. ×5. (The smaller outline figure shows the natural size.)

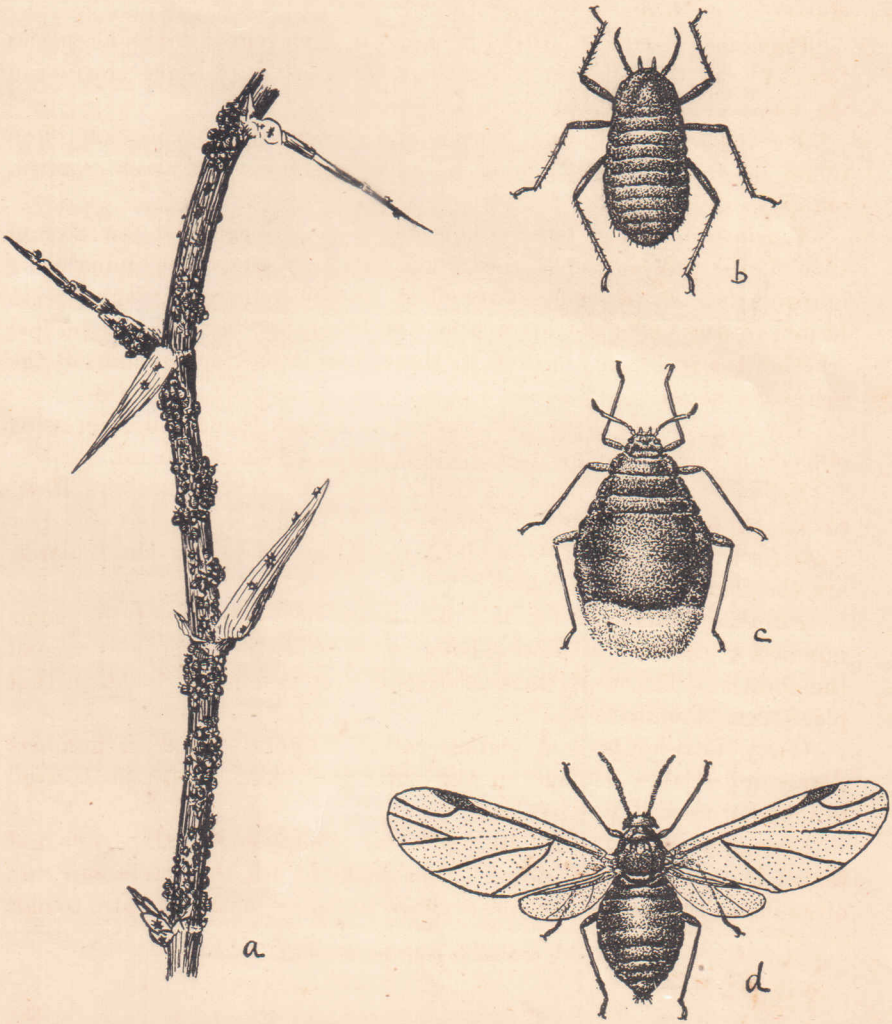


Fig. 2.—Woolly Aphid on bamboo ; *a*, Aphids clustered on bamboo shoot ; *b*, young Aphid ×40 ; *c*, wingless adult ×13 ; *d*, winged adult ×11.

Of mealy-wings we have chiefly the *Dialeurodes eugeniæ* on *Eugenia* and Aleurodids on *Bassia* and *Citrus*.

Of plant-lice pests we have several, and of these the chief are those found on cotton, tobacco, *Citrus*, *lab lab*, cow-pea and *cholam*.

Bamboo Woolly Aphis. On bamboo we occasionally find a species of woolly aphis coming in large colonies (Pl. 19, fig. 2). It is not the same as Fletcher's fig. 392.

The Coconut Aphis (*Cerataphis lataniæ*), Fletcher's fig. 393, has not been noted since.

Coming to Scales and Mealy-bugs there are a good many species of importance. In a paper I prepared for the Session of the Indian Science Congress held at Lahore in 1918, I listed 32 species of Coccids having some economic importance. Though all these are not bad pests at present, some of them are really important. Of these mention might be made here of the following.

Pulvinaria maxima, Gr., a bad pest of *nîm* trees (*Melia azadirachta*).

Ceroplastodes cajani, on *lab lab* stems and *Ocimum ;* often bad.

Anomalococcus indica, Gr., on *babul* (*Acacia arabica*).

Pseudococcus sacchari. Bad on paddy. The disease is called *Soorai novu* in Tamil and often reported from Tanjore, Trichinopoly and Madura districts. Fields badly attacked show the infestation patches here and there.

Phenacoccus insolitus. Bad on brinjal plants, Madras, Coimbatore, etc.

Ripersia sacchari. On sugarcane stems. This is the commonest species of mealy-bug on cane, and is different from *Pseudococcus sacchari*.

Icerya ægyptiaca. On jak, Malabar and Nilgiris. This is the species to which I referred at the last meeting (p. 152 of Report).

Hemichionaspis aspidistræ. On pepper in Malabar, and also on *Ficus* leaves elsewhere.

Aspidiotus tamarindi. On tamarind, Coimbatore, etc.

Phenacoccus iceryoides. On mango ; in Coimbatore, Northern Circars and Tanjore.

Pseudococcus corymbatus. On cotton, mango and jak. In different places.

Aspidiotus aurantii. On rose, Malabar.

Aspidiotus curcumæ or *hartii*. On turmeric rhizomes at Coimbatore.

Pseudococcus longispinus ? Bad inside leaf-sheaths of young coconut trees ; Coimbatore, Malabar and South Kanara.

Orthoptera.

Among grasshoppers no new pest of any importance has been noted. The wingless grasshopper, *Orthacris* sp., was however found pretty bad

on mulberry plots in Kollegal more than once. And on one occasion surface-grasshoppers of the genera *Æolopus* and *Œdaleus* were noted very bad in paddy nurseries in one village in the Coimbatore district.

THYSANOPTERA.

Very little attention has been paid till now to the insects of this group and there is little on record regarding their economic importance. In South India the following species have been noted so far, as having some economic importance :—

On paddy. *Thrips* (*Bagnallia*) *oryzæ* on seedlings in many parts of the Province. Pretty bad sometimes. (Some p. 353, *Bulletin of Entomological Research*, 1915, for description of this species by Williams).

On turmeric and arrowroot. *Panchætothrips indicus*, Bagn. (Plate 20). On turmeric in Coimbatore and on arrow-root in Malabar. Not serious.

On onion. *Heliothrips indicus*, Bgl. Bad sometimes in Northern Circars.

On grape-vine. *Rhipiphorothrips cruentatum*, Hood. On tender grape-vine leaves. Turns the leaves pale brown. Found in numbers on the foliage at certain seasons.

On *Mimusops elengi*. *Arrhenothrips ramakrishnæ*, Hood, (Plate 99)· Very serious on this garden plant in Coimbatore. The leaves are very badly twisted and galled.

Thrips of sorts have also been noted doing some damage to chillies, indigo, etc., in different parts of the country.

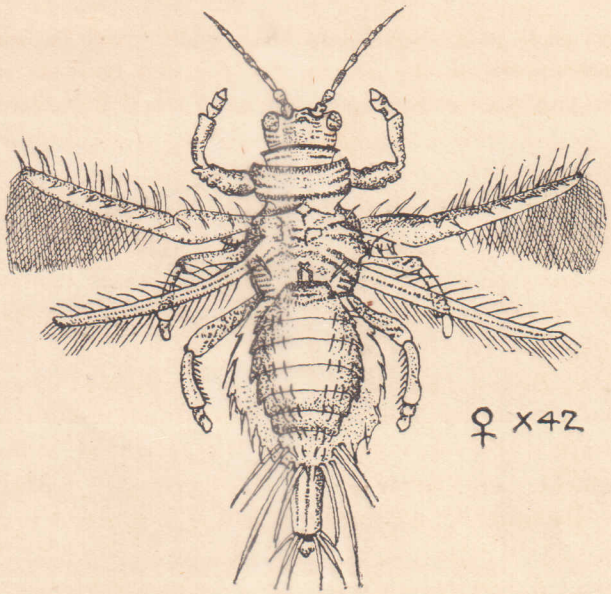
On groundnut.—In the Palur farm a species of Thrips was once reported doing serious damage.

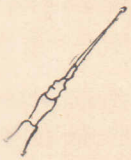
Just a few words regarding non-hexapod pests of some importance may not be out of place before I close. Small Mites of sorts have been noted occasionally bad on cotton, *cholam*, castor and coconut ; those on *cholam* and cotton have often been found to do appreciable damage.

The others among non-hexapods are the eel-worms. I have seen young tea-seedlings and pepper-vines suffer from the attacks of eel-worms. In one or two places eel-worms appeared bad on pepper in the Wynaad last November [1918].

The question of crabs on paddy seedlings has become well-known and needs no further remarks from me.

As already stated in the beginning, my chief idea in getting this list prepared was to gather more information regarding all or any of these





Panchætothrips indica, Bgll., on arrow-root leaves.

from observations made by my colleagues in other parts of India so that our information regarding these forms may be kept as up-to-date as possible.

Bulletin No. 101 1921

Agricultural Research Institute, Pusa

Some Insects recently noted as Injurious in South India

BY

T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S.,

Acting Government Entomologist, Madras

(Reprinted from the Proceedings of the Third Entomological Meeting.)

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1921

In this paper I have attempted to bring together a very brief account of these recently noted forms. Of course, casual references and stray notes of some of these have appeared in reports and departmental papers but nowhere in a connected and complete manner.

The list is neither complete (it can never be complete for many a long time to come), nor does it profess to give any detailed accounts of the different forms. It is more or less a skeleton list forming a sort of supplement to Mr. Fletcher's valuable volume, and the only reason for its publication is to bring together our scattered and necessarily incomplete knowledge of these forms into a connected shape as a sort of nucleus for future work. There is little doubt that, as our knowledge of these insects increases, it may be possible to bring out further papers containing detailed information on each of these forms. In the list, I have included not only those insects that have been recently noted as of some economic importance, but also others, which though already known and recorded, have not been sufficiently recognized as injurious in South India. The forms are arranged under their natural Orders and with regard to many which have not yet been scientifically identified, I have given popular names by means of which each might be recognized until it gets its scientific baptism.

Hymenoptera.

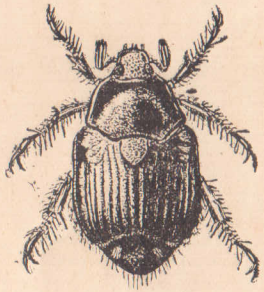
Eurytoma indi, Girault[1]. (Plate 9, fig. *f*.)—This is a small wasp of the family Eurytomidæ included in the large group of Chalcidid wasps. Most of the insects of this group are parasitic on other insects and as such beneficial in many cases to the cultivator. This species, however, seems to be one among the exceptions. The adult insect is black with the abdomen shining; measures 2·25 mm. It breeds inside seeds of *dhaincha* (*Sesbania ægyptiaca*) pods and destroys the seed. The insect was noted on the Coimbatore farm three years ago doing serious damage to a crop of *dhaincha* left for seed. A smaller insect, also a Chalcidid, *Megastigmus indi*, Gir., has been noted along with it and is believed to be a parasite on the seed-borer.

In general form and habits this borer appears very closely allied to the American 'Clover-seed Chalcid' (*Bruchophagus funebris*, How).[2]

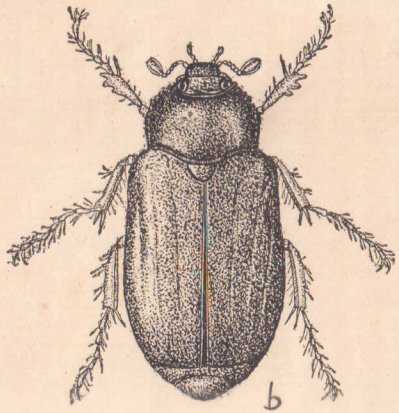
Philanthus ramakrishnæ, Turner. (Plate 11, fig. 1.)—This fossorial wasp is one of the many insect enemies of the honey-bee (*Apis indica*) in the Hills of South India. I first noted this on the Bababudin Hills in

[1] The name given to this insect in the *Report of the 2nd Entomological Conference, Pusa*, (p. 73), is a mistake.

[2] See *Monthly Bulletin Calif. St. Com. Hort.*, Vol. II, p. 696 (1913).

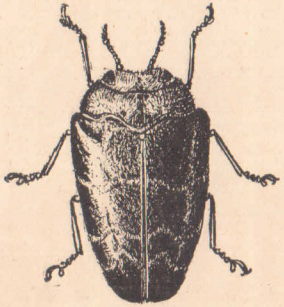


a

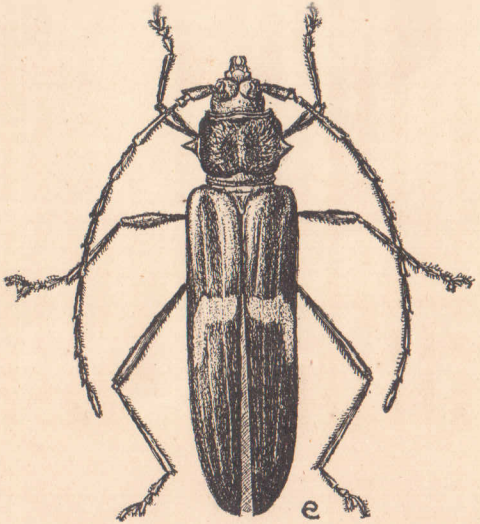


b

c



d



e

f

South Indian Insects.—*a*, *Popillia chlorion* ×2⅛; *b*, *Rhizotrogus rufus* ×2⅛; *c*, *Apomecyna perotteti* ×2⅛; *d*, *Trachys bicolor* ×7; *e*, *Chelidonium cinctum* ×2⅛; *f*, *Eurytoma indi* ×13.

Edited by

The Council of the Pusa Agricultural Research Institute, which is not, as a body, responsible for the opinions expressed in the Bulletin.

Mysore at an elevation of 4,000 feet. It has latterly been noted on the Palnis also. Numbers of the honey-bee are carried off by this wasp and stored in nests made in hard banks at the sides of hill roads. There is no doubt that hives of honey-bees are depopulated in this way by this insect. Interesting accounts of how species of these wasps hunt bees and store them, will be found in Fabre's interesting works.

Xylocopa tenuiscapa, Westw. In buildings where the roofing materials are of bamboo or weak and unseasoned wood this carpenter-bee causes considerable damage. The rafters and beams are riddled with holes inside which the insect breeds. Swarms of these insects are found hovering about the building all day long with their characteristic disturbing noise. I have collected the Meloid beetle *Cissites debyi* in the galleries made by this bee. This latter insect is believed to be predaceous on the larvæ of the carpenter-bee.

Among other Hymenoptera already recorded as injurious, mention may be made of two well-known ants—*Œcophylla smaragdina* and *Camponotus compressus*. The former was recently found bad on the crowns of coconut trees in South Kanara. It is found very hard to get rid of the nests on these trees ; tree-climbers often suffer very much. The latter is chiefly found guilty of spreading colonies of scale-insects from tree to tree ; this has been noted especially in the case of two Coccids on the Coimbatore farm, *viz.*, *Pulvinaria maxima*, Gr., and *Anomalococcus indicus*, Gr.

Coleoptera.

Holotrichia sp. (Plate 9, fig. *b*.)* This is a fairly big cockchafer beetle, chocolate-brown in colour. Mr. Arrow of the British Museum, to whom it was sent, says that the species is new to the Museum. Thousands of these emerge from the soil at the hill-sides soon after the first summer rains on the Nilgiris. The grubs are generally found active from September to November. In certain years these do considerable damage to young cinchona seedlings. Thousands of the adults may be caught at lights in May—June. Another known species, *H. repetita*, is occasionally found with this species, but not in such numbers, on the Nilgiris.

Lopillia chlorion, Newm. (Plate 9, fig. *a*.) This small pretty green insect is found in company with the big cockchafer noted above, and the grubs too have the same habits, but are smaller in size. Cockchafer grubs of sorts have now and then been observed also under *cholam* plants and other garden shrubs on the Coimbatore farm.

---

* Since described in *Ann. Mag. Nat. Hist.*, July 1919, p. 24, by Mr. Arrow as *Rhizotrogus rufus*.

Anadastus sp. Within the past three or four years the *tenai* crop (*Setaria italica*) on the Coimbatore farm has been found subject to the attacks of a Languriad borer. The nature of the damage and the external symptoms of the crop are similar to those caused by ordinary borers—the fading and gradual death of the shoots and ears, and death of the plant. The beetle appears to be a species of *Anadastus;* another Erotylid which I have noted as a borer till now is *Fatua longicornis*, W., breeding on dry and rotting *Euphorbia antiquorum* plants (See Fletcher, p. 290). The life-history of this *tenai* beetle has recently been worked out by my Assistant, Mr. P. V. Isaac. The eggs are thrust into the stem at the nodes singly, a few inches above the ground level. The grub feeds from inside and pupates in the hollow. The beetle is small in size, about 6 mm. in length, and red and blue in colour.

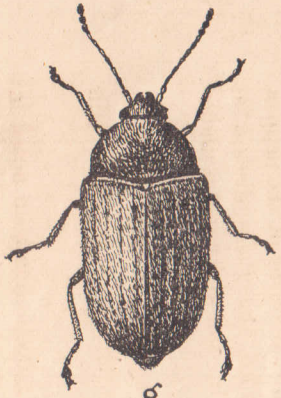
Anthrenus pimpinellæ, Fab., var. (Fig. 76 in Fletcher's book.) Silk and woollen goods are found subject to the attacks of a small Dermestid in South India. The beetle is very small, oval in shape and dark brown in colour with white patches on the elytra. The small dark hairy larva is found feeding on silk cocoons, woollens, brushes, etc. *Anthrenus fasciatus* has been reported more than once from Army clothing depôts.

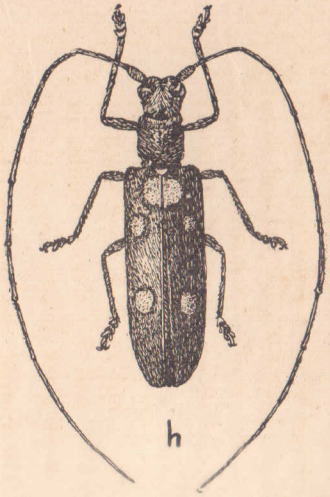
Trachys bicolor. (Plate 9, fig. *d*.) The *palas* tree (*Butea frondosa*) is subject to the serious attacks of this Buprestid leaf-miner. In the months from December to March, when fresh leaves are put out by the bushes, every leaf is found mined and blistered by this borer. The beetle is comparatively small in size and dark bluish in colour. It is very common in South Malabar.

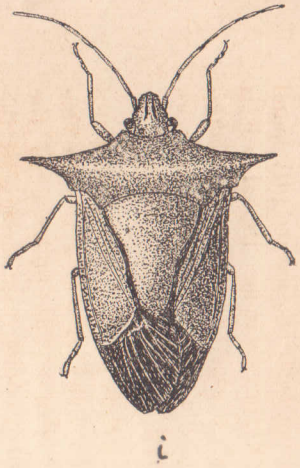
A species of *Trachys* is referred to as a pest of jute in Bengal (vide *Report of Second Entomological Meeting*, p. 134) but I do not know which species this one is.

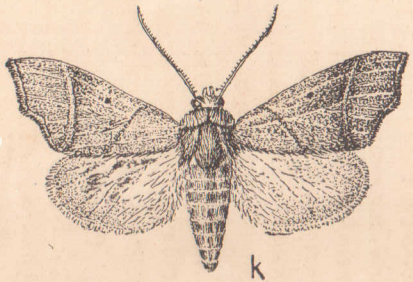
Wire-Worms. Reports of Elaterid grubs attacking potatoes in the Hills have been recently received. The actual species concerned has yet to be bred out.

The *Moringa* stem-borer. The larva, which in this case is a longicorn borer, attacks the *moringa* tree (*Moringa pterygosperma*). The beetle is a typical Lamiad appearing more or less like one of the species of *Monohammus*. It is about 19 mm. long and greyish-brown in colour. The insect is found occasionally serious. The life-history has recently been worked out by my Assistant Mr. T. V. Subramania Ayyar. [See paper No. 66 of these Proceedings.]









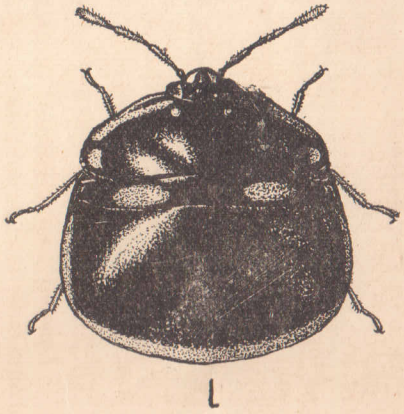


PLATE 10.

South Indian Insect Pests ; *g, Kolingi* **pod beetle** ×13 ; *h, Olenecamptus bilobus* ×2$\frac{1}{2}$; *i, Vitellus orientalis* ×2$\frac{1}{2}$; *j, k, Carea subtilis,* **larva and moth** ×$\frac{1}{3}$; *l, Coptosoma naziræ* ×13 ; *m, Clovia lineaticollis* ×5.

Chelidonium cinctum, Guer. (Plate 9, fig. *e*.) Mr. Anstead, the Deputy Director of Agriculture for Planting Districts, has recently found this insect attacking *Citrus* trees in the Mysore uplands. Probably it is similar in habits to the other well-known orange-borer of Coorg, *Chloridolum alcmene*. It may be the same or similar to one noted in Coorg by Fletcher (See *Rept. of Second Entomological Meeting*, p. 211).

The *Morinda* shoot borer. This insect is a very small pale-brown beetle, the whitish grubs of which are found attacking the growing terminal shoots of *Morinda tinctoria* plants. The presence of the pest is easily seen by the faded and drooping appearance of the young distal shoots ; the latter turn black in course of time and drop down. The larva is a minute pale white grub ; the pupa is also found in the same place. The beetle appears to be a Scolytid, having an oval prothorax and small brownish head tucked underneath the thorax.

The *Kolingi* pod beetle. (Plate 10, fig. *g*.) As a green-manure plant in wet areas, the *kolingi* or wild indigo (*Tephrosia purpurea*) is held in high esteem in South India. Seeds are regularly collected and even sold by the Department. The growing pods of this bush are attacked by a small beetle borer—an Anthribid, probably a species of *Arœcerus* —which eats away the seeds and makes the pod empty. The pupa is also found inside the attacked pod. The insect is found in Tinnevelly, Tanjore and South Arcot districts. The adult beetle is very small in size, 2·5 mm. long, pale greyish in colour and is almost similar in appearance to the *kolingi* seed. It is a very active creature.

Longitarsus nigripennis, Motsch. The grub of this small flea-beetle contributes a share to what is called the *Pollu* disease of pepper in North Malabar. The adult beetle is a very active small creature with the head and thorax ochraceous and the elytra bluish-black ; the hind femora are extraordinarily thick. Eggs are thrust singly just under the rind of the growing pepper-berry ; the small cream-white grub feeds on the inner contents of the berry and makes it hollow—this hollowing of the pepper-berry, to whatever cause it is due, being called the *Pollu* disease of pepper. The mature grub drops down into the soil and pupates underground enclosed in an earthen cell.

There are also other species of flea-beetles which are often noted as sporadic local pests causing a certain amount of damage to crops in certain seasons. Of these the following are the chief :—

The *Bael* flea-beetle. This dark shining beetle has been noted in Coimbatore and Kollegal doing damage to the foliage of bael, *Ægle marmelos*. They feed together in numbers and cause considerable

damage within a short period of time. It does not appear to be *Clitea picta*, Baly.

The *Panivaragu* flea-beetle. This small flea-beetle appears to be a specific pest of the millet *Panicum miliare* in Coimbatore ; the larvæ bore into the plant stem and often cause " dead hearts."

The Radish flea-beetle. This small very active bright-blue insect is found doing serious damage often to cabbage, radish and other cruciferous plants. It is also occasionally found on other irrigated crops but the insect is very partial to Cruciferæ. It appears to be similar to a flea-beetle which I remember to have collected on brinjal in Muzaffarpur in October 1904.

Other flea-beetles are those found on sann hemp, castor, etc.

Green potato leaf-beetle. A shining green Galerucine beetle is found on the Nilgiris feeding on potato-leaves in some numbers. Similar beetles have also been noted on sweet-potato in Tinnevelly and other places—but not as bad pests.

Several species of *Myllocerus* are now and then noted on various cultivated crops but only a few of these species ever do any appreciable damage and even this is not of common occurrence. The following species may however be watched.

Myllocerus subfasciatus, Guer. This species is a grey insect commonly found on a variety of plants. Noted on brinjal, potatoes, apple, etc. Sometimes the insect causes serious damage to brinjal foliage in the Plains.

Myllocerus discolor. This weevil is the common greyish-brown species found on a variety of crops all over South India. It has been noted on maize, *ragi*, *cholam*, etc. In bad seasons and when the plants are young this weevil does appreciable damage to the crop, although in normal years the work of the insect is negligible.

Myllocerus dentifer, F. This pale-greyish beetle is occasionally found defoliating *tenai* (*Setaria*), *cumbu*, etc., in South Arcot.

Myllocerus viridanus. This pretty green species is generally found on groundnut, castor, *Hibiscus esculentus*, etc. Stebbing notes this insect as a bad pest on teak in the Walayar forests. With this species is often found a smaller species, *M. pretiosus*, F.

Corresponding perhaps to the species of *Myllocerus* in the Plains we have one or two species of *Sympiezomias* on coffee, cinchona, etc., in the Hills. The species noted so far are *S. frater*, *S. cretaceus*, and *S. decipiens*.

Alcides pictus. (Pl. 11, f. 2). This species of *Alcides*, which is not unknown in South India, has within the last two or three years taken to feed on *lablab*. The grubs and pupæ are found infesting the main vines and some damage is done to the plant.

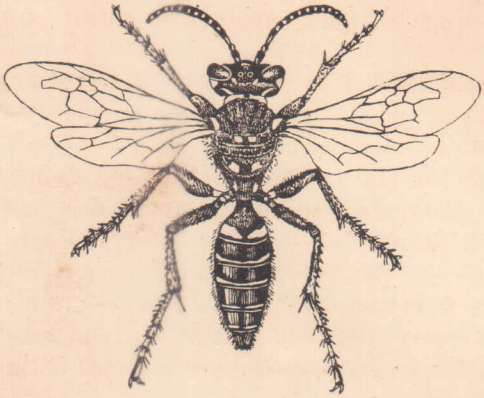


Fig. 1.—*Philanthus ramakrishnæ*, Turner, $\times 2\frac{3}{5}$. The lower figure shows a specimen in flight, carrying off a honey-bee.

Fig. 2.—*Alcides pictus*, natural size and magnified ($\times 5$).

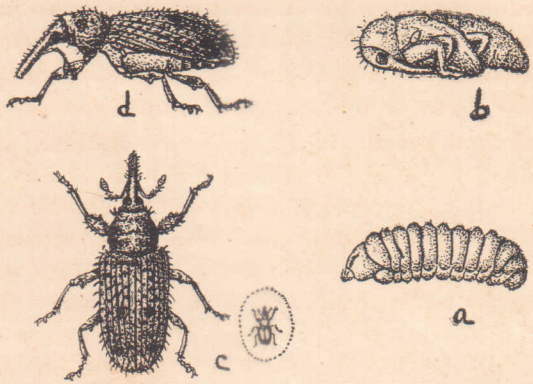


Fig. 1.—Jak Weevil ; *a*, larva ×8 ; *b*, pupa ×8 ; *c*, beetle, dorsal view, natural size and enlarged (×8) ; *d*, beetle, side-view, ×8.

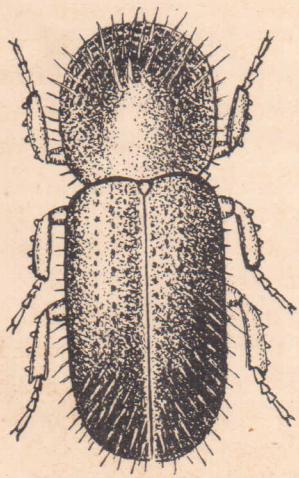


Fig. 2.—Rubber Scolytid (×36).

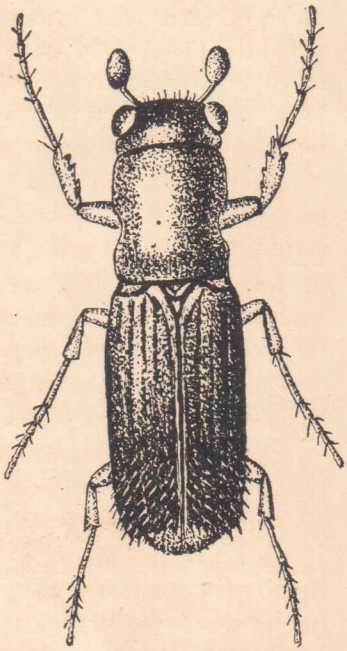


Fig. 3.—Rubber Platypodid (×16).

Conarthrus jansoni, Woll. In the coastal tracts of Malabar and Cochin I have noted a small shining black beetle boring in numbers into the bamboo framework of sheds and fences near houses. The split bamboo pieces are badly tunneled in some cases. Fletcher has noted a beetle of similar habits in Ceylon (*Myocalandra exarata*, Boh.), but I find that this insect is not the same as the Ceylonese one.

The Jak-fruit weevil (Pl. 12, f. 1). In Malabar and the Mysore uplands young fruits of jak trees are sometimes very badly damaged by this insect. The weevil is a very small one, measuring about 6 mm. in length, and is pale-greyish-brown in colour. The snout is prominent. Hundreds of the small cream-white grubs are found riddling healthy tender fruits and as a consequence the fruits shrivel up and drop down. Dr. Marshall, to whom I sent specimens some time back, tells me that the insect belongs probably to a new genus and that he would describe the same soon.

Calandra rugicollis, Fst. This small weevil has been noted as a pest of *sal* (*Shorea robusta*) seedlings in Ganjam. In appearance it is more or less like the ordinary rice *Calandra* but slightly bigger. All fallen *sal* seeds contain the grubs and pupæ of this weevil. This was noted by a nephew of mine who is a Forest Officer. It appears closely allied to the acorn weevil (*C. sculpturata*, Gyll.) mentioned by Stebbing, and is perhaps the same as the undetermined '*Sal* weevil' referred to by Stebbing on page 450 of his book on Indian Forest Insects.

Rubber Scolytid.* (Pl. 12, f. 2). A small reddish-brown Scolytid beetle (very likely a species of *Xyleborus*) was recently sent up from a rubber estate in Cochin as doing damage to *Hevea* bark.

Rubber Platypodid. (Pl. 12, f. 3). This was reported from Travancore doing the same kind of damage to rubber bark. The insect from its structure appears to be a species of Platypodid.

Coconut Scolytid. A small Scolytid, said to damage coconut stems, has been received two or three times from different parts of South India.

The real bionomics of these Scolytids have to be studied to see whether they are the cause or the effect in these different cases, since in the case of rubber a fungus disease is often found mixed up.

Two weevils—Melon weevil (*Acythopeus citrulli*, Marsh) and a small Apion (*Apion amplum*, Fst.) may also be added to the list of weevils. The former was noted in Cuddapah and Bellary inside melons, and the latter has been collected on *Anacardium* fruits in Malabar and also breeding in green-gram pods in Coimbatore.

---

* Since named by Col. Winn Sampson as *Xylsborus biporus*, n. sp.

Before leaving beetles, I may add a few remarks on the following insects which have already been noted as injurious, just to point out their present status in view of our further knowledge of these insects.

Pempheres affinis. This insect has within the past two or three years distributed itself with Cambodia cotton into tracts where it was not found till now—*viz.*, Madura, Ramnad and Tinnevelly districts. It appears that the weevil exists in different parts where no cotton is grown —for I noted the weevil on *Hibiscus esculentus* in North Malabar—and makes itself prominent with the introduction of cotton cultivation. The life-history of the insect has been worked out and an account of it will be found in my paper on this insect in the *Year Book of the Madras Department of Agriculture* for 1918 (pp. 1—13) [*Coloured plate exhibited*].

Alcides bubo. (Plate 13). This insect continues to be a bad pest of *Sesbania* (*agathi*) in betel-vine gardens. The plants do not suffer much when they have grown 4 or 5 feet high ; but during the younger stages very serious damage is done. Two or three applications of lead arsenate during the earlier stages at intervals of a fortnight checked the attack in the early stages. I am exhibiting a coloured plate showing the different stages of this pest. Two parasites *Metastenomyia juliani*, Gir., and *Eurytoma pigra*, Gir., have been noted on the grub ; but not to any great extent. In page 97 of the *Madras Departmental Year-Book* for 1917 is a short paper of mine on the egg-laying habits of this insect.

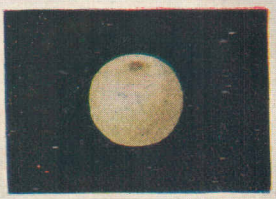
Alcides affaber. This is a specific pest of gogu (*Hibiscus cannabinus*) and is also found on *Hibiscus esculentus ;* pretty bad occasionally. *Alcides leopardus*, Ol., mentioned by Fletcher in his book, is apparently a wrong identification for *A. affaber*, for I have never seen *A. leopardus* anywhere in Coimbatore. I, however, got some specimens of this latter species breeding on a wild plant in South Malabar a couple of years ago.

Peltotrachelus pubes—a weevil noted in the Shevaroys on orange This is a minor pest only.

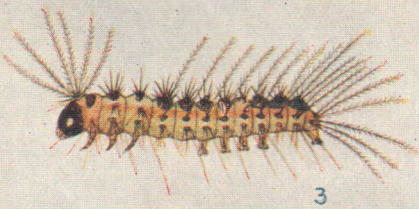
Apoderus tranquebaricus. Recently this insect has been noted in numbers on tender shoots and leaves of mango trees in Chittur and adjacent mango tracts. (Reference to my note in *Bulletin of Second Hundred Notes*).

Pachytychius mungonis, originally noted on green-gram, is also found on *dhaincha* as a pretty bad pest, causing prominent swellings of the stem

Olenecamptus bilobus (Plate 10, figure *h*), though noted by Lefroy in his *Indian Insect Life*, is not in Fletcher's book. It is sufficiently important to be grouped as a pest. I have noted this doing damage to cultivated figs in Krishna, Bangalore, and other places. It was once noted on pomegranate also in Salem, Coimbatore.

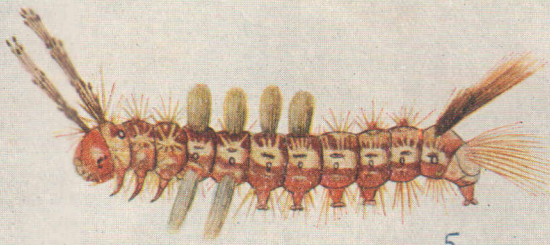


2



3

4

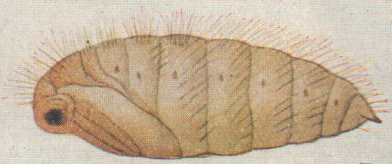


5

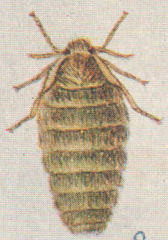
8

6

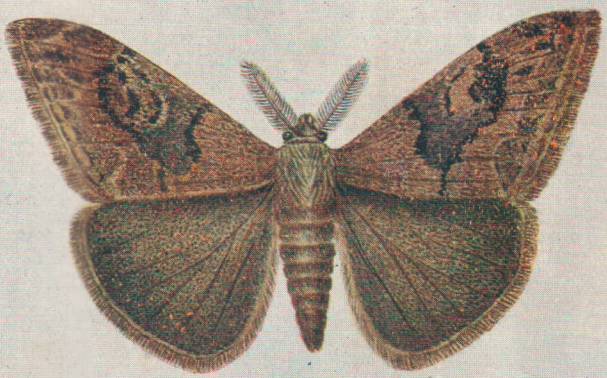
1



7



9



10

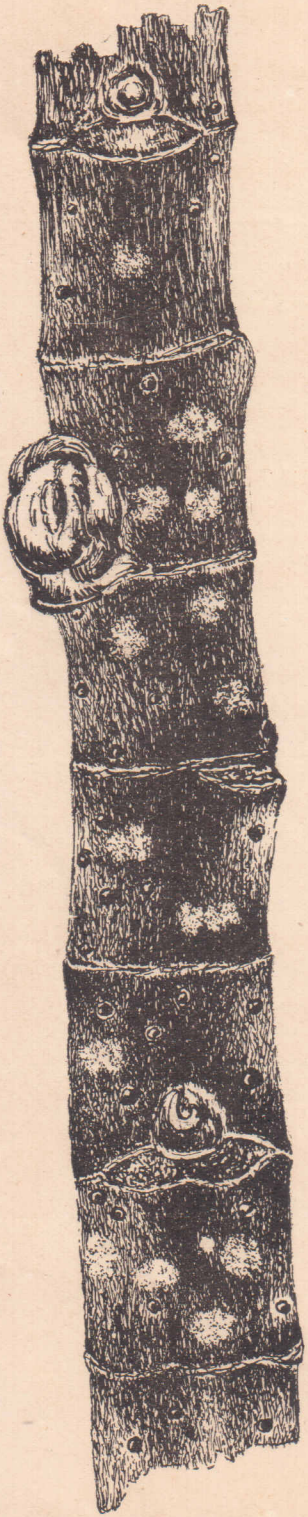
ORGYIA POSTICA.

EXPLANATION OF PLATE 13.

Alcides bubo.

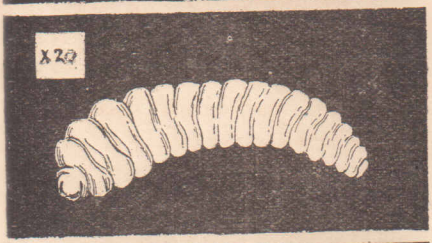
Fig. 1. Stem cut open, showing eggs deposited in it ($\times 1\frac{1}{3}$).
Fig. 2. A single egg, magnified ($\times 33$)
Fig. 3. Newly-hatched larva ($\times 30$).
Fig. 4. Full-grown larva ($\times 10$).
Fig. 5. Stem attacked by larva, showing galls.
Fig. 6. Stem cut open, showing larval workings ($\times 1\frac{1}{3}$).
Fig. 7. Pupa, magnified ($\times 8$).
Fig. 8. Adult beetle ($\times 1\frac{1}{2}$).
Fig. 9. Pair of beetles ($\times 1\frac{1}{2}$).
Fig. 10. Beetle, side-view ($\times 5$).
Fig. 11. Beetle, dorsal view ($\times 5$).
Fig. 12 Chalcidid parasite ($\times 10$).

ALCIDES BUBO.



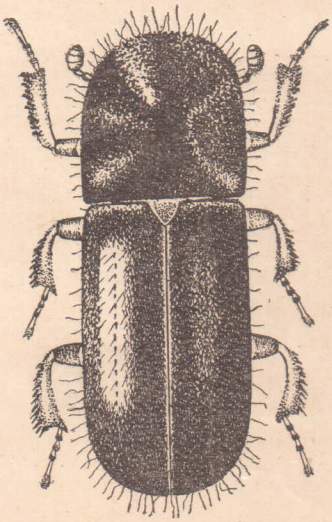
a

b



c

d



e

Shot-hole Borer (*Xyleborus fornicatus*) of castor-stem at Bangalore. *a*, castor stem bored by beetles ; *b*, eggs ×16 ; *c*, larva ×20 ; *d*, pupa ×24 ; *e*, beetle, ×24.

Apomecyna perotteti (Plate 9, figure *c*) has recently been noted in Godavari and Vizagapatam districts as a pretty bad pest of cucurbits, especially of the vegetable called *dondekaya* in Telugu.

Among Bruchids of economic importance the following might be noted.—

Bruchus analis—on stored pulses.

B. theobromæ—breeding on red-gram in the fields.

B. chinensis—both in the fields and in the store room.

Other unidentified species are, one species breeding on *lab lab* in the fields, one on cow-pea also in the field, and another from *agathi* (*Sesbania*) pods in the field. The correct identification of these species is a matter of great importance, as confusion is sure to arise.

Xyleborus fornicatus (Pl. 14) was once noted pretty bad on a species of red garden castor plant in Bangalore. Being a well-known pest of tea and other plants in Ceylon, and this being the first record of it in the Plains, it is necessary that the progress of this pest should be watched carefully.

The Bostrichid, *Rhizopertha dominica*, which was till now considered a minor pest of stored cereals, has during the past two or three years proved a serious pest of stored paddy. This was the case in the Coromandel districts two years ago.

The weevil, *Tylopholis ballardi*, mentioned in Marshall's *Fauna* volume, has been noted attacking Bengal gram in Bellary, but has not been noted as serious.

Lepidoptera.

Chilades laius. This Lycænid is occasionally noted doing damage to *Citrus* shoots in the Northern Circars.

Parata alexis. The larva of this Skipper is found sporadically in numbers attacking the foliage of *Pongamia glabra*, a tree the leaves of which are largely used for green-manure in wet-lands.

Psychidæ. Among bag-worms we often have trouble with some species. One is sometimes found on castor in Coimbatore (probably *Psyche vitrea*), and another on fruit-trees in the Northern Circars, especially on *Sapota*.

Contheyla rotunda. A sporadic serious pest of coconut trees on the South Malabar coast. It has also been noted by Mr. Anstead as a pest of tea in the Hills. (See my paper on this insect, p. 91, *Madras Departmental Year-Book 1917*.)

Natada nararia was once found as a bad pest of the garden hedge plant, *Pithecolobium dulce*, in Coimbatore.

Butea Limacodid. A stout spiny caterpillar similar to *Parasa* but bigger in size. Moth grey with ochraceous markings. Found defoliating *Butea frondosa* in the Bolampatty forests, Coimbatore.

Carea subtilis (Plate 10, figs. *j*, *k*) very common on *Eugenia jambolana* in different parts. The caterpillar with the swollen anterior portion is easily made out. A parasite has been noted on this, *Tumidicoxoides jambolana*, Gir MS.

Cirphis albistigma (Plates 15, 16). A pretty bad pest of ripening paddy. The caterpillar is the climbing caterpillar of paddy of the Coromandel coast, appearing generally after the heavy North-East Monsoons, January to February. The caterpillar cuts down the ripening ear-heads.

Adisura atkinsoni. A Noctuid borer of *lab lab* pods. Very common in Coimbatore and the Northern Circars during the cold weather. (See *Year Book of Madras Department*, 1917, p. 87, for Mr. Y. Ramachandra Rao's paper on its life-history).

Euzophera plumbeifasciella has been found breeding inside wood-apple fruits.

Ephestia cautella, on stored groundnut pods; the caterpillar bores into the pod and eats the seeds. Often bad in stores of unshelled groundnuts.

Heterographis bengalella, a Pyralid with olive greenish upper wings. Larva found inside the fruits of custard apple.

Corcyra cephalonica. The stored rice meal-worm. Very common in South India. Found on rice and meal of all cereals.

Chrysanthemum caterpillar. A small green caterpillar was found once pretty bad on cultivated chrysanthemum in Madura. The moth is of medium size and has ochraceous wings. Probably a species of *Hypargyria* (Pyralidæ).

Brachmia effera, Meyr. The small caterpillar folds the leaf of sweet-potato; has not become serious yet.

Laspeyresia leucostoma. Found near Kateri and Coonoor on the Nilgiris. The caterpillar feeds on the leaf of tea.

Cyphosticha cærulea. The pinkish small caterpillar mines into the leaf tissue of *lab lab* and produces a sort of prominent white blister on the leaf. Pretty bad in Coimbatore and Malabar.

Phthorimœa blapsigona. A common pest of brinjal buds in South India. A species of *Microbracon* is found as a parasite of this caterpillar.

Phyllocnistis toparcha, Meyr. The larva mines into grape-vine leaves and the mine is seen in the form of glistening wavy lines on the leaf in Coimbatore.

Acrocercops syngramma, Meyr., on tender mango leaves, Madras.

Publications of the Imperial Department of Agriculture in India.

To be had from :—

The Office of the Agricultural Adviser to the Government of India, Pusa, Bihar, and from the following Agents :—

1. Thacker, Spink & Co., Calcutta.
2. W. Newman & Co., Calcutta.
3. Rai M. C. Sarkar Bahadur & Sons, Calcutta.
4. Higginbothams, Ltd., Madras.
5. Thompson & Co., Madras.
6. D. B. Taraporevala, Sons & Co., Bombay.
7. Thacker & Co., Ltd., Bombay.
8. Sunder Pandurang, Bombay.
9. Rai Sahib M. Gulab Singh & Sons, Lahore.
10. Manager, Educational Book Depôt, Nagpur.

A complete list of the publications of the Imperial Department of Agriculture in India can be obtained on application from the Agricultural Adviser to the Government of India, Pusa, Bihar, or from any of the above mentioned agents.

These publications are :—

1. The *Agricultural Journal of India.* A Journal dealing with subjects connected with agricultural economics, field and garden crops, economic plants and fruits, soils, manures, methods of cultivation, irrigation, climatic conditions, insect pests, fungus diseases, co-operative credit, agricultural cattle, farm implements, and other agricultural matters in India. Illustrations, including coloured plates, form a prominent feature of the Journal. It is edited by the Agricultural Adviser to the Government of India, and is issued once every two months or six times a year. *Annual Subscription,* Rs. 6 or 9*s.* 6*d.*, including postage. Single copy, R. 1-8 or 2*s.*
2. Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Imperial Cotton Specialist).
3. Annual Report on the Progress of Agriculture in India.
4. Proceedings of the Board of Agriculture in India.
5. Proceedings of Sectional Meetings of the Board of Agriculture.
6. Memoirs of the Imperial Department of Agriculture in India :
   - (*a*) Botanical Series.
   - (*b*) Chemical Series.
   - (*c*) Entomological Series.
   - (*d*) Bacteriological Series.
   - (*e*) Veterinary Series.
7. Bulletins issued by the Agricultural Research Institute, Pusa.
8. Books.

The following are the publications of the last two years :—

Scientific Reports of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist), for the year 1918-19. Price, R. 1-4 or 2*s.*

Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Secretary, Sugar Bureau), for the year 1919-20. Price, R. 1.

Report on the Progress of Agriculture in India for the year 1917-18. Price, R. 1-8 or 2*s.* 3*d.*

Report on the Progress of Agriculture in India for the year 1918-19. Price, R. 1-8 or 2*s.* 3*d.*

Proceedings of the Board of Agriculture in India, held at Pusa on the 1st December, 1919, and following days (with Appendices). Price, As. 12 or 1*s.* 3*d.*

Proceedings of the Second Meeting of Mycological Workers in India, held at Pusa on the 20th February, 1919, and following days. Price, As. 11 or 1*s.*

Proceedings of the First Meeting of Agricultural Chemists and Bacteriologists, held at Pusa on 24th February, 1919, and the following days. Price, R. 1 or 1*s.* 6*d.*

Proceedings of the First Meeting of Veterinary Officers in India, held at Lahore on the 24th March, 1919, and following days (with Appendices). Price, As. 8 or 9*d.*

Proceedings of the Third Entomological Meeting, held at Pusa in February, 1919. Price, Rs. 17-8.

MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA.

Botanical Series.

Vol. X, No. I. The Rice Worm (*Tylenchus angustus*) and its Control, by E. J. BUTLER, M.B., F.L.S. Price, R. 1-4 or 2*s*.

Vol. X, No. II. Studies in Indian Sugarcanes, No. 4. Tillering or Underground Branching, by C. A. BARBER, C. I. E., SC.D., F.L.S. Price, R. 4-4 or 7*s*.

Vol. X, No. III. Studies in Indian Sugarcanes, No. 5. On testing the suitability of sugarcane varieties for different localities, by a system of measurements. Periodicity in the growth of the sugarcane, by C. A. BARBER, C.I.E., SC.D., F.L.S. Price, R. 1-12 or 3*s*.

Vol. X, No. IV. A *Pythium* Disease of Ginger, Tobacco and Papaya, by L. S. SUBRAMANIAM. Price R. 1-8 or 2*s*. 6*d*.

Vol. X, No. V. Studies in the Pollination of Indian Crops, 1, by A. HOWARD, C.I.E., M.A.; GABRIELLE L. C. HOWARD, M.A.; and ABDUR RAHMAN KHAN. Price R. 1-4 or 2*s*. 6*d*.

Vol X, No. VI. "Kumpta" Cotton and its Improvement, by G. L. KOTTUR, B. Ag. Price, R. 1-12 or 3*s*.

Vol. XI, No. I. Some Aspects of the Indigo Industry in Bihar. Part I. The Wilt Disease of Indigo. Part II. The factors underlying the seed production and growth of Java Indigo, by ALBERT HOWARD, C.I.E., M.A., and GABRIELLE L. C. HOWARD, M.A., with the assistance of CHOWDHARY RAMDHAN SINGH and MAULVI ABDUR RAHMAN KHAN. Price, R. 1-2 or 2*s*.

Vol. XI, No. II. Studies in Diseases of the Jute Plant. (1) *Diplodia Corchori*, Syd., by F. J. F. SHAW, D.SC., A.R.C.S., F.L.S. (*In the press.*)

Vol. XI, No. III. Morphology and Parasitism of *Acrothecium Penniseti* n. sp. (A new Disease of *Pennisetum typhoideum*), by MANORANJAN MITRA, M.SC. (*In the press.*)

Chemical Series.

Vol. V, No. IV. Cholam (*A. Sorghum*) as a Substitute for Barley in Malting Operations, by B. VISWANATH, T. LAKHSHMANA ROW, B.A., and P. A. RAGHUNATHASWAMI AYYANGAR, D.P. AG. Price, As. 12 or 1*s*.

Vol. V, No. V. The Phosphate Requirements of some Lower Burma Paddy Soils, by F. J. WARTH, M.SC., B.SC., and MAUNG PO SHIN. Price, R. 1-12 or 3*s*. 3*d*.

Vol. V, No. VI. Absorption of Lime by Soils, by F. J. WARTH, M.SC., B.SC., and MAUNG PO SAW. Price, R. 1-2 or 2*s*.

Vol. V, Nos. VII & VIII. The Gases of Swamp Rice Soils, V—A. Methane-oxidizing Bacterium from Rice Soils, by P. A. SUBRAHMANYA AYYAR, B.A.; and The Gases of Swamp Rice Soils, VI—Carbon Dioxide and Hydrogen in relation to Rice Soils, by W. H. HARRISON, D.SC. Price, As. 12 or 1*s*. 3*d*.

Vol. V, No. IX. The Retention of Soluble Phosphates in Calcareous and Non-calcareous Soils, by W. H. HARRISON, D.SC., and SURENDRA LAL DAS, M.SC. (*In the press.*)

Vol. V, No. X. Windrowing Sugarcane in the North-West Frontier Province. Part I.—The Effect on the Economical and Agricultural situation, by W. ROBERTSON BROWN. Part II.—The Effect on the Composition of Sugarcane, by W. H. HARRISON, D.SC., and P. B. SANYAL, M.SC. Price, As. 12 or 1*s*.

Entomological Series.

Vol. V, No. V. The Rice Leaf-hoppers (*Nephotettix bipunctatus*, Fabr. and *Nephotettix apicalis*, Motsch.), by C. S. MISRA, B.A. Price, R. 1-8 or 3*s*.

Vol. V, No. VI. *Lantana* Insects in India. Being the Report of an Inquiry into the Efficiency of Indigenous Insect Pests as a Check on the Spread of *Lantana* in India, by RAO SAHIB Y. RAMACHANDRA RAO, M.A., F.E.S. Price, R. 2-4 or 4*s*. 6*d*.

Vol. VI, Nos. I—IX. Life-histories of Indian Insects: Microlepidoptera, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S. Price, Rs. 7-8 or 11*s*. 3*d*.

Vol. VII, Nos. I & II. New Indian Gall Midges (Diptera), by E. P. FELT, and Description of a Rhinocyphine larva from Shillong, by MAJOR F. C. FRASER, I.M.S. Price, As. 12 or 1*s*. 6*d*.

MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA—*contd.*

Bacteriological Series.

Vol. I, No. VIII. Pebrine in India, by C. M. HUTCHINSON, C.I.E., B.A. Price, Rs. 3-8 or 5*s.* 6*d.*
Vol. I, No. IX. Studies on the Root Nodule Organism of the Leguminous Plants, by N. V. JOSHI, M.SC., B.A., L.AG. Price, R. 1-4 or 2*s.* 6*d.*

Veterinary Series.

Vol. III, No. II. The Virulence of Tubercle Bacilli isolated from Bovine Lesions in India, by A. L. SHEATHER, B.SC., M.R.C.V.S. (*In the press.*)
Vol. III, No. III. Bovine Lymphangitis, by A. L. SHEATHER, B.SC., M.R.C.V.S. (*In the press.*)

BULLETINS ISSUED BY THE AGRICULTURAL RESEARCH INSTITUTE, PUSA.

No. 85. Soil Drainage, by R. G. ALLAN, M. A. Price, As. 4 or 5*d.*
No. 86. A. New Nematode causing Parasitic Gastritis in Calves, by A. L. SHEATHER, B.SC., M.R.C.V.S. Price, As. 4 or 5*d.*
No. 87. A Contribution to our Knowledge of South Indian Coccidæ, by T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S. Price, As. 14 or 1*s.* 6*d.*
No. 88. Cawnpore-American Cotton : An Account of Experiments in its Improvement by Pure Line Selection and of Field Trials, 1913-1917, by B. C. BURT, B.SC., and NIZAMUDDIN HAIDER. Price, As. 10 or 1*s.*
No. 89. Second Hundred Notes on Indian Insects. Price, R. 1-4 or 2*s.*
No. 90. A Malarial Parasite in the Blood of a Buffalo, by A. L. SHEATHER, B.SC., M.R.C.V.S. Price, As. 6 or 7*d.*
No. 91. Notes on Practical Salt Land Reclamation, by G. S. HENDERSON, N.D.A., N.D.D. Price, As. 6.
No. 92. Syngamus laryngeus in Cattle and Buffaloes in India, by A. LESLIE SHEATHER, B.SC., M.R.C.V.S., and A. W. SHILSTON, M.R.C.V.S. Price As. 6.
No. 93. The Orange : A Trial of Stocks at Peshawar, by W. ROBERTSON BROWN. Price As. 6.
No. 94. A Preliminary Note on the Behaviour in North India of the first batch of Sugarcane Seedlings distributed from the Sugarcane-breeding Station, Coimbatore, by T. S. VENKATRAMAN, B.A. Price, As. 8.
No. 95. A Note on the Treatment of Surra in Camels by Intravenous Injections of Tartar Emetic, by H. E. CROSS, M.R.C.V.S., D.V.H., A.SC. Price, As. 2.
No. 96. A Summary of Experiments on Rice in Bihar and Orissa from 1912 to 1919, by G. C. SHERRARD, B.A. (*In the press.*)
No. 97. *Ustilago Crameri*, Koern. on *Setaria italica*, by S. SUNDERARAMAN, M.A. Price,
No. 98. The Course that Surra runs in Camels when Naturally Contracted and when Artificially Inoculated, by H. E. CROSS, M.R.C.V.S., D.V.H., A.SC. (*In the press.*)
No. 99. The Course that Camel Surra runs in Ponies, Buffaloes and other Animals, by H. E. CROSS, M.R.C.V.S., D.V.H., A.SC. (*In the press.*)
No. 100. Annotated List of Indian Crop-Pests, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S. Price, R. 1-8.
No. 101. Some Insects recently noted as injurious in South India, by T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S. Price, As. 8.
No. 102. Borers in Sugarcane, Rice, etc., by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. GHOSH, B.A. Price, R. 1.
No. 103. Some Indian Economic Aleyrodidæ, by C. S. MISRA, B.A. Price, As. 8.
No. 104. The Rice Leaf-hoppers, by C. S. MISRA, B.A. Price, As. 6.
No. 105. Cotton Bollworms in India, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. S. MISRA, B.A. Price, As. 8.
No. 106. The Pink Bollworm in Egypt, by LEWIS H. GOUGH, PH.D., F.E.S. Price, R. 1.
No. 107. Experiments in Egypt on the Survival of the Pink Bollworms (resting stage larvæ) in ripe damaged Cotton Bolls buried at different depths, by F. C. WILLCOCKS. Price, As. 5.
No. 108. Some Pests of Cotton in North Bihar, by C. S. MISRA, B.A. Price, As. 6.
No. 109. *Tukro* Disease of Mulberry, by C. S. MISRA, B.A. Price, As. 4.
No. 110. The Preservation of Wood against Termites, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. GHOSH, B.A. Price, As. 3.

BULLETINS ISSUED BY THE AGRICULTURAL RESEARCH INSTITUTE, PUSA—*contd.*

No. 111. Stored Grain Pests, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. GHOSH, B.A. Price, As. 14.

No. 112. Notes on Rearing insects in hot Climates, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. Ghosh, B.A. Price, As. 7

No. 113. Hints on Collecting and Preserving Insects, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S. Price, As. 10.

No. 114. The Preparation and Reproduction of Scientific Illustrations, by A. W. SLATER. Price, As. 4.

No. 115. Note on Plant Imports into India, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S. Price, As. 7.

INDIGO PUBLICATIONS.

No. 6. The Effect of Manuring with Superphosphate and Sannai on the Yield of Crops on Indigo Planters' Estates in Bihar—especially of Rabi Crops in the Season 1918, 1919, by W. A. DAVIS, B.SC., A.C.G.I. Price, As. 6.

No. 7. The Conditions affecting the Quality of the Java Indigo Plant (Leaf yield and richness of the leaf in indigotin), by W. A. DAVIS, B.SC., A.C.G.I. Price, As 9.

No. 8. Note on the Development of the Indigo Industry in Assam in conjunction with Tea and other Crops, by W. A. DAVIS, B.SC., A.C.G.I. (*In the press.*)

BOOKS.

"Indian Insect Pests," by H. MAXWELL LEFROY, M.A., F.E.S., F.Z.S. Price, R. 1-8 or 2*s.* (*Out of print.*)

"Indian Insect Life," by H. MAXWELL LEFROY, M.A., F.E.S., F.Z.S.; and F. M. HOWLETT, B.A. 786 pp. Price, R. 20 or 30*s.* (*Out of print.*)

"Wheat in India," by ALBERT HOWARD, M.A., A.R.C.S., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. 288 pp. Price, R. 5 or 7*s.* 6*d.*

"A Description of the Imperial Bacteriological Laboratory, Muktesar: Its Work and Products," by Major J. D. E. HOLMES, M.A., D.SC., M.R.C.V.S. Price, As. 8 or 9*d.*

"Agriculture in India," by JAMES MACKENNA, M.A., I.C.S. Price, As. 4 or 5*d.*

"Some Diseases of Cattle in India. A Handbook for Stock: owners." Price, As. 8 or 9*d.*

"The Importance of Bacterial Action in Indigo Manufacture," by C. M. HUTCHINSON, B.A. Price, As. 2 or 3*d.*

Report of the Indian Cotton Committee. Vol. I, Report; Vol II, Maps and Plans. Price, R. 1 per volume. (Superintendent, Government Printing, India, Calcutta.)

Minutes and evidence taken before the Indian Cotton Committee:—

Vol. I. Agriculture, Part I (United Provinces, Central Provinces, Burma, North-West Frontier Province, Punjab and Sind). Price, Rs. 2-6.

Vol. II. Agriculture, Part II (Bombay, Madras, Bengal, Bihar and Orissa, Imperial Officers, Central India, Baroda, Hyderabad and Mysore). Price, Rs. 2-13.

Vol. III. Irrigation (United Provinces, Central Provinces, North-West Frontier Province, Bengal and Sind). Price, R. 1-12.

Vol. IV. Commercial, Part I (United Provinces, Central Provinces, Burma, Punjab, Sind and Bombay). Price, Rs. 2-2.

Vol. V. Commercial, Part II (Madras, Bengal, Imperial Officers, Central India, Baroda and Hyderabad). Price, R. 1-12.

SGPI—M—98 AA to G of I—12-5-21—1,000

Bulletin No. 112 1921

Agricultural Research Institute, Pusa

Notes on Rearing Insects in Hot Climates

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist,

AND

C. C. GHOSH, B.A.,
Assistant to the Imperial Entomologist

(Reprinted from the Proceedings of the Third Entomological Meeting.)

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1921

Price As. 7.

EXPLANATION OF PLATE 17.

Orgyia postica.

Fig. 1. Mass of eggs, natural size.
Fig. 2. Egg, magnified (×13).
Fig. 3. Newly-hatched larva, magnified.
Fig. 4. Full-grown larva, natural size.
Fig. 5. „ „ „ magnified (×2½).
Fig. 6. Cocoon, natural size.
Fig. 7. Pupa, magnified (×2½).
Fig. 8. Female moth, natural size.
Fig. 9. „ „ magnified (×1½).
Fig. 10. Male moth, magnified (×2½).

Edited by

The Council of the Pusa Agricultural Research Institute, which is not, as a body, responsible for the opinions expressed in the Bulletin.

Bulletin No. 112

1921

Agricultural Research Institute, Pusa

Notes on Rearing Insects in Hot Climates

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist,

AND

C. C. GHOSH, B.A.,
Assistant to the Imperial Entomologist

(Reprinted from the Proceedings of the Third Entomological Meeting.)

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1921

Agents for the Sale of Books Published by the Superintendent of Government Printing, India, Calcutta.

IN EUROPE.

Constable & Co., 10, Orange Street, Leicester Square, London, W.C.

Kegan Paul, Trench, Trübner & Co., 68-74, Carter Lane, E.C., and 25, Museum Street, London, W.C.

Bernard Quaritch, 11, Grafton Street, New Bond Street, London, W.

P. S. King & Sons, 2 & 4, Great Smith Street, Westminster, London, S.W.

H. S. King & Co., 65, Cornhill, E.C., and 9, Pall Mall, London, W.

Grindlay & Co., 54, Parliament Street, London, S.W.

Luzac & Co., 46, Great Russell Street, London, W.C.

W. Thacker & Co., 2, Creed Lane, London, E.C.

T. Fisher Unwin, Ltd., 1, Adelphi Terrace, London, W.C.

Wm. Wesley & Son, 28, Essex Street, Strand, London.

B. H. Blackwell, 50 & 51, Broad Street, Oxford.

Deighton Bell & Co., Ltd., Cambridge.

Oliver and Boyd, Tweeddale Court, Edinburgh.

E. Ponsonby, Ltd., 116, Grafton Street, Dublin.

Ernest Leroux, 28, Rue Bonaparte, Paris.

Martinus Niihoff, The Hague, Holland.

IN INDIA AND CEYLON.

Thacker, Spink & Co., Calcutta and Simla.

Newman & Co., Calcutta.

R. Cambray & Co., Calcutta.

S. K. Lahiri & Co., Calcutta.

B. Banerjee & Co., Calcutta.

The Indian School Supply Depôt, 309, Bow Bazar Street, Calcutta, and 226, Newabpur, Dacca.

Butterworth & Co. (India), Ltd., Calcutta.

Rai M. C. Sarcar Bahadur & Sons, 19/2A, Harrison Road, Calcutta.

The Weldon Library, 57, Park Street, Calcutta.

Standard Literature Co., Ltd., Calcutta.

Lalchand & Sons, Calcutta.

Association Press, Calcutta.

Higginbotham & Co., Madras.

V. Kalyanarama Iyer & Co., Madras.

G. A. Natesan & Co., Madras.

S. Murthy & Co., Madras.

Thompson & Co., Madras.

Temple & Co., Madras.

P. R. Rama Iyer & Co., Madras.

Vas & Co., Madras.

M. R. Ry. E. M. Gopalakrishna Kone, Madura.

Thacker & Co., Ltd., Bombay.

A. J. Combridge & Co., Bombay.

D. B. Taraporevala, Sons & Co., Bombay.

Radhabai Atmaram Sagoon, Bombay.

Sunder Pandurang, Bombay.

Gopal Narayan & Co., Bombay.

Ram Chandra Govind & Son, Kalbadevi, Bombay.

Proprietor, New Kitabkhana, Poona.

The Standard Bookstall, Karachi.

Mangaldas Harkisan Das, Surat.

Karsandas Narandas & Sons, Surat.

A. H. Wheeler & Co., Allahabad, Calcutta and Bombay.

N. B. Mathur, Supt., Nazir Kanun Hind Press, Allahabad.

Munshi Seeta Ram, Managing Proprietor, Indian Army Book Depot, Juhi, Cawnpore.

Rai Sahib M. Gulab Singh & Sons, Mufid-i-Am Press, Lahore and Allababad.

Rama Krishna & Sons, Lahore.

Supt., American Baptist Mission Press, Rangoon.

Manager the "Hitavada" Nagpur.

S. C. Talukdar, Proprietor, Students and Company, Cooch Behar.

A. M. & J. Ferguson, Ceylon.

Manager, Educational Book Depôts, Nagpur and Jubbulpore.*

Manager of the Imperial Book Depôt, 63, Chandney Chauk Street, Delhi.*

Manager, "The Agra Medical Hall and Co-operative Association, Ltd." (Successors to A. John & Co., Agra).*

Supt., Basel Mission Book and Tract Depository, Mangalore.*

P. Varadachary & Co., Madras.*

H. Liddel, Printer, etc., 7, South Road, Allahabad.*

D. C. Anand & Sons, Peshawar.*

Ram Dayal Agarwala, 184, Katra, Allahabad.*

Manager, Newal Kishore Press, Lucknow.*

* Agents for the Sale of Legislative Department publications only.

54.—NOTES ON REARING INSECTS IN HOT CLIMATES.

By T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., *Imperial Entomologist*, and C. C. Ghosh, B.A., *Assistant to the Imperial Entomologist.*

(Plates 131—138).

The importance of rearing insects needs little emphasis here. The identification of insects being based as a rule on adult characters, in the case of an immature form found doing damage it is usually necessary

to rear it into an adult in order to know what it is. And a knowledge of early stages and life-histories (in the fullest sense of the word) of any insect pest is a necessity in any consideration of control methods.

The necessity for such knowledge, however, is by no means equivalent to its acquisition, and those who have attempted the rearing of large numbers of insects under tropical conditions will doubtless agree that such rearing is decidedly an art only to be acquired by dint of much trouble and patience, often accompanied by numerous set-backs and disappointments.

In order to assist those who wish to rear insects in India, therefore, we have in the following paper jotted down a few notes based on our own experience in the hope that it may be of some use to others.

The main condition of success in rearing all insects is to provide them as far as possible with absolutely natural conditions of life. A caterpillar, for example, under natural conditions lives in the open air on a growing plant, whose leaves remain constantly fresh ; when it is full-fed it may burrow into the ground and pupate under the soil which remains at an optimum degree of moisture. If we catch that caterpillar and shut it up in a cardboard box or glass bottle with some leaves of its food-plant, the leaves will wither and dry up, or their contained moisture may be condensed on the sides of the glass bottle, and the caterpillar is at once placed under unhealthy and unnatural conditions of existence and food ; similarly, if it pupates in earth in a box, the earth may dry up or become too moist, with the result that the pupa dries up also or is killed off by mould. The above may be an exceptional case. It is really wonderful under what adverse conditions many caterpillars will live and (apparently) thrive. But in any case it is necessary as a first condition of success that, to ensure successful rearing, insects should be provided with :—

(1) fresh food,
(2) fresh air, or at least sufficient air,
(3) correct conditions of moisture,
(4) sanitary surroundings.

Growing plants, if they can be utilized in this way, provide the most natural and therefore most satisfactory means of rearing all insects feeding on such plants. The plants may be grown in pots or other receptacles containing earth and the potted plants with the insects living on them may be enclosed in cages. Or the plants may be grown in large cages provided with a sufficiency of soil. Or, in the case of plants growing out of doors, the plants themselves may be covered over with a cage pressed down into the soil around them, or they may be " sleeved," *i.e.*, the plant or a branch is covered with a single or double-ended bag

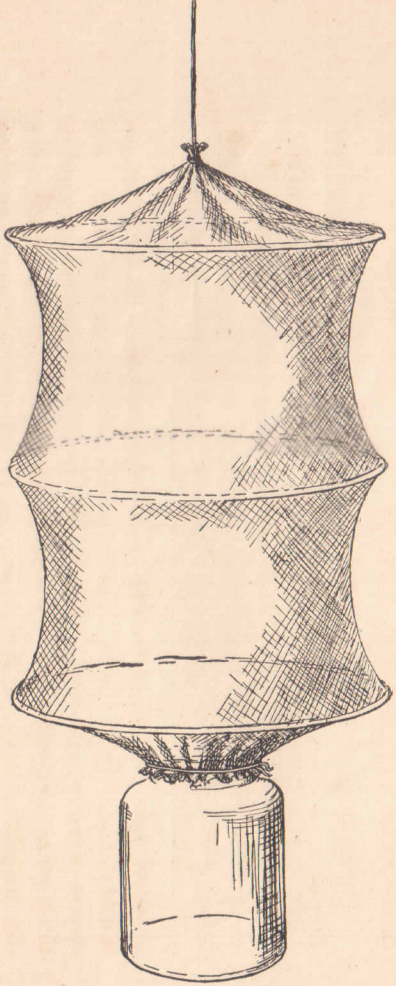


Fig. 1.—A meat-safe used as a rearing-cage.

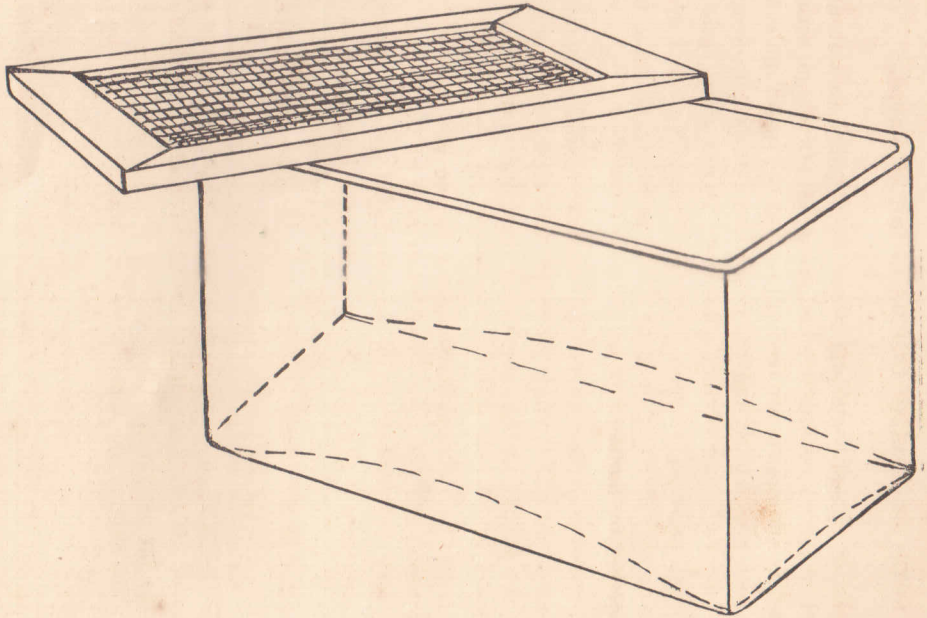


Fig. 2.—Glass Trough with wire-gauze cover.

made of muslin or mosquito-netting whose open end is tied around the stem of the plant (or whose ends are tied around a branch on either side of the place where the insects are feeding) so that the insect under rearing is allowed to feed under fairly natural conditions but cannot escape outside of the "sleeve." "Sleeving," however, is not very satisfactory in a country such as India, as such "sleeves" quickly rot and are very liable to tear or may be torn open by birds or other animals or even removed altogether by human bipeds.

Generally, therefore, it is necessary to rear insects such as caterpillars on cut portions of their foodplants placed within closed receptacles and in such cases the effect of a hot climate at once makes itself felt. Cut portions of plants, which in a cool climate would remain tolerably fresh for a day or more, wilt almost immediately in the hot weather whilst during the monsoon the plant-food and excrement of the insects under rearing form very favourable media for the rapid growth of moulds. Especial care therefore is required to keep the breeding cages (of whatever construction) quite clean by removing all excreta and uneaten leaves at least once a day, if not oftener. Otherwise, mould will quickly appear on these and the insects are likely to be affected.

For casual rearing on a small scale a small meat-safe makes a convenient cage, the necessary foodplant being kept fresh by having its stalk inserted in a jar of water. Or a collapsible meat-safe (of the type made of mosquito-netting stretched over bamboo rings) may be placed over the jar or bottle containing the foodplant and tied securely around the neck of the jar, the upper end being suspended by a string from any convenient support. If the stalk of the foodplant does not fill the neck of the jar, the latter should be packed with a thick wad of cotton-wool, otherwise caterpillars are very liable to crawl down and drown themselves in the water. (Pl. 131, Fig. 1.)

For more regular rearing of insects, however, it is necessary to provide proper apparatus, which comprises :—

Glass jars and troughs.
Zinc cages.
Zinc cylinders.
Muslin cages.

Glass jars. At Pusa we use glass dishes and glass battery jars (as illustrated in Pl. 132) in different sizes, from small to large. For covers of these cages we use either glass plates with one side ground or brass plates (Pl. 132). In dry weather leaves kept in cages retain moisture for several days and remain fit to serve as food to the insects to which they are supplied. In moist weather in the rains, however, whole covers

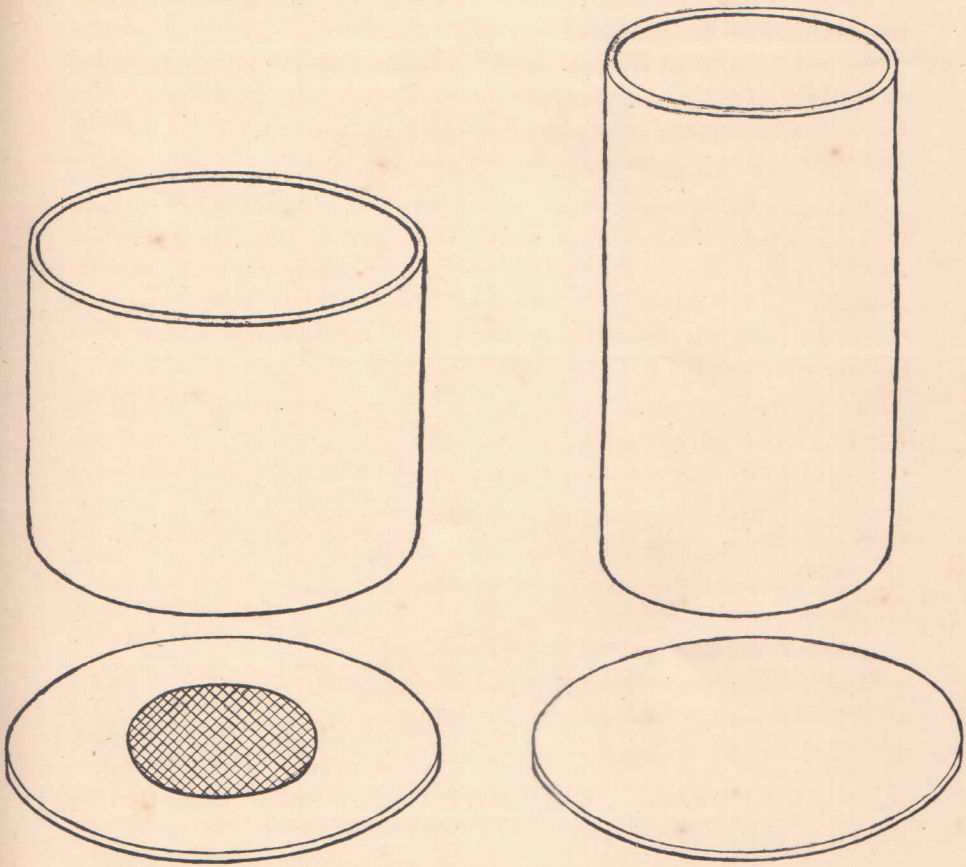
are unsuitable and we use brass plates with a large hole in the middle, the hole being protected with fine brass wire gauze soldered on to the plate (see figure). In these cages the moisture can be regulated almost to perfection by the use of these perforated brass covers, the holes in them being left, when necessary, either entirely open or partly covered by glass or brass sheets placed on the top. As a result we have hardly any trouble from mould in the rearing cages. For those insects which pupate underground, such as Noctuid larvæ, a layer of moist earth is provided at the bottom of the cage and they can without further attention go into the earth and pupate there. The earth keeps moist for very long periods. Therefore it is not necessary to disturb the insects at all.

The glass dishes and jars are used as small aquaria for insects which feed on aquatic leaves, for example, *Nonagria pallida* and *Nymphula* whose caterpillars feed on floating leaves of *Nelumbium*, or *Galerucella singhara* feeding on floating leaves of *Trapa*. When used as aquaria the cages are covered with muslin. For larger aquaria we use glass troughs shown in figure 2, on Plate 131.

There are some insects which can be included among the leaf eaters but which live underground as a rule, only coming up, usually at night, to collect food, such as caterpillars of *Agrotis* and nymphs of the Large Brown Cricket (*Brachytrypes portentosus*). For them the glass jars are filled with moist earth and leaves or cut plants placed on the surface of the earth.

There is another class of insects which form silken tubes underground, the tubes serving as galleries in which they live. For them also the glass jars and troughs are used with success. The caterpillars of *Ancylolomia chrysographella* not only require earth to form galleries but also living plants, rice or grasses, on the leaves of which they feed. The caterpillars of *Melasina*, *Lamoria*, *Myrmecozela*, *Machæropteris* and others require earth in which they can form galleries and are fed with leaves and grasses placed on the surface of the earth.

Zinc Cages. Grasshoppers have been reared successfully in these glass jars. But on account of their saltatorial habits they are somewhat cramped for space in these cages. They are best placed on potted plants in the large zinc breeding cages illustrated in Pl. 133, fig. 1. These cages measure 24 inches in height and 12 inches across each side and are provided with a hinged door. The door and the wall opposite to it are of wire gauze with about 16 meshes to the inch. The other two walls are of glass. The entire framework and the roof and floor are made out of galvanized iron sheet. We also use similar cages of a smaller size measuring 12 inches in height about 8 inches across each



Glass Dish (left) and Battery Jar (right) with whole (right) and perforated (left) metal covers.

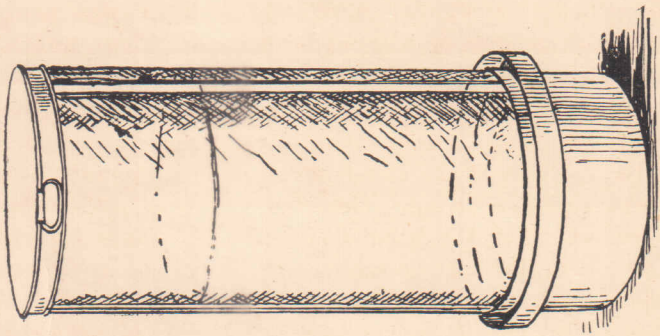


Fig. 2.—Gauze Cylinder.

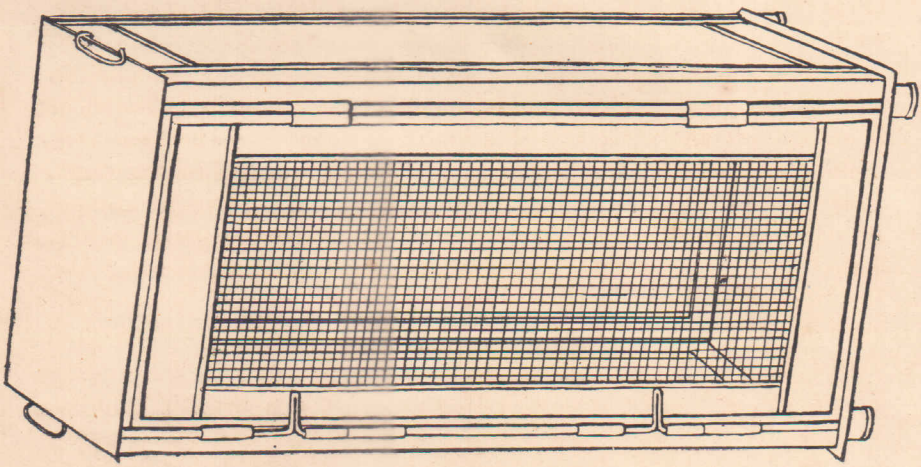


Fig. 1.—Zinc Breeding Cage.

EXPLANATION OF PLATE 15.

Cirphis albistigma.

Fig. 1. Eggs laid on paddy leaf, magnified.
Fig. 2. Larva, first instar (×45).
Fig. 3. Larva, second instar (×25).
Fig. 4 Larva, third instar (×13).
Fig. 5. Larva, fifth instar (×8).
Fig. 6 Larva, sixth instar (×4).

side. When required for small parasites, etc., thin muslin or silk gauze is gummed over the wire gauze.

Zinc Cylinders. For *Nymphula depunctalis* the glass jars proved too small. The caterpillars require rice plants growing in water, so that they can float and swim in water and crawl upon the plants. For them the zinc cylinder illustrated in Pl. 134, fig. 1 was used. These cylinders are either with or without a bottom. Those with a bottom can be used as aquaria. In the case of *Nymphula depunctalis* caterpillars, one with a bottom was used. Living rice plants were transferred into it with a quantity of earth and it was partly filled with water. A long stick, stood in the middle, supported the muslin which formed the covering. The zinc cylinders without a bottom can be pressed into the ground over living plants and when the plants are low the wire gauze cover illustrated in figure 2 serves the purpose well. For taller plants the covers shown in Pl. 133, fig. 2 are used. The cylinders are made out of thin galvanized iron sheets and are 2 feet in diameter. All round the top on the outside there is a channel about an inch in depth and breadth which can be filled with kerosenized water to prevent access of ants or escape of creeping insects. On the inside the top is provided with a sloping piece intended to prevent escape of insects. This can, however, be done away with.

The cage illustrated in Pl. 135, fig. 1 is made by pinning thin muslin on a wooden frame. The bottom is made of wooden board. The door is on one side and is fitted with a long muslin sleeve. This is a very useful cage and serves many purposes better than the zinc breeding cages. Moths and flies kept in it do not dash against hard surfaces as in cages having glass or wire gauze sides in their flight or attempts at escape. Therefore in such cases the risk of injury to them is very small. Also the sleeved door is more advantageous than the hinged door of zinc cages. There is hardly any possibility of insects escaping through it during manipulation.

Having provided ourselves with the principal apparatus required, we can now proceed to consider the various groups into which insects may be classified according to their feeding habits and hence according to the manner in which it is necessary to rear them. In this way insects may be classified as :—

(1) Scavengers of dead—
  (*a*) animal matter,
  (*b*) vegetable matter.

(2) Predators on other animals.

(3) Parasites of other animals—
  (*a*) external parasites,
  (*b*) internal parasites.
(4) Feeders on living plants :—
  (*a*) leaf-eaters,
  (*b*) leaf-miners,
  (*c*) gall-makers—
    (1) in leaves,
    (2) in petioles,
    (3) in stems ;
  (*d*) borers—
    (1) in stems,
    (2) in roots,
    (3) in flowers,
    (4) in fruits,
    (5) in seeds ;
  (*e*) root-feeders,
  (*f*) sap-suckers.
(5) Aquatic insects.

Scavengers of dead animal matter, such as many Sarcophagids, Muscids, Phorids and other Diptera, and Scarabæids, Silphids and other Coleoptera, require moist conditions and should be provided with moist food and moist earth. They are easily reared as a rule if their appropriate food is placed on a little earth.

A few Lepidopterous and Coleopterous feeders on dead animal matter (such as *Trichophaga* on furs, *Tinea* and *Anthrenus* on woollens, and *Necrobia* on dried meat) are also easily reared in the presence of their particular food, but require fairly dry conditions.

Scavengers of dead vegetable matter, such as those beetles which live in dry grain or wood, depend little on external conditions and can be reared out easily. But those which feed in rotting vegetable matter, such as Nitidulids, require to be kept under moist conditions.

Predators. Among the predators which bite, the Mantids, Carabids, Coccinellids, as also the Phorids and Syrphids and those which suck, the Myrmeleonids, Ascalaphids, Chrysopids, Pentatomids and Reduviids, require an ample supply of food and are indifferent to dry or moist conditions. The Carabids, however, pupate underground and require a supply of moist earth. The larvæ of stinging predators, Eumenids, Sphegids, etc., and in fact, all Hymenopterous larvæ except probably those of Tenthredinids which behave like caterpillars, require a good deal of

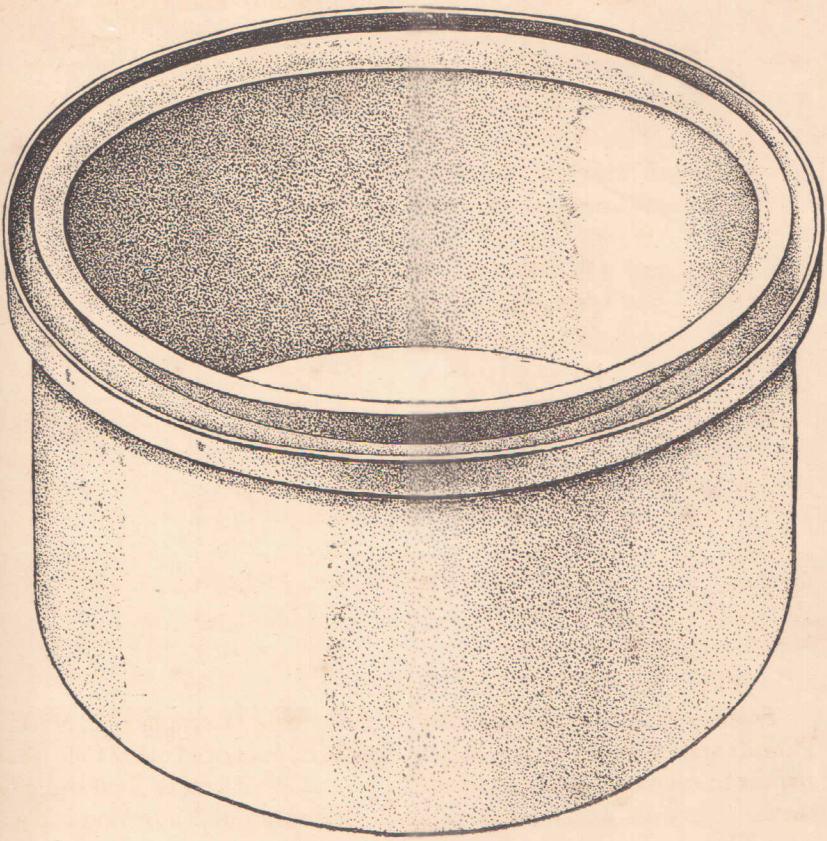


Fig. 1.—Zinc cylinder.

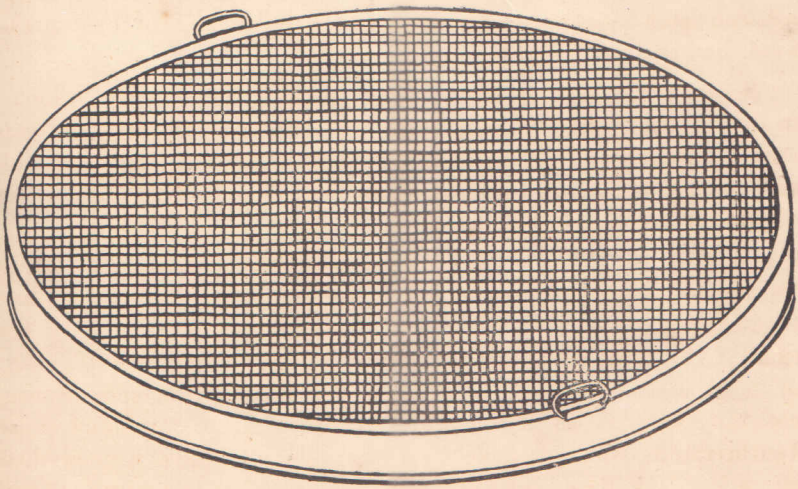


Fig. 2.—Cover for zinc cylinder.

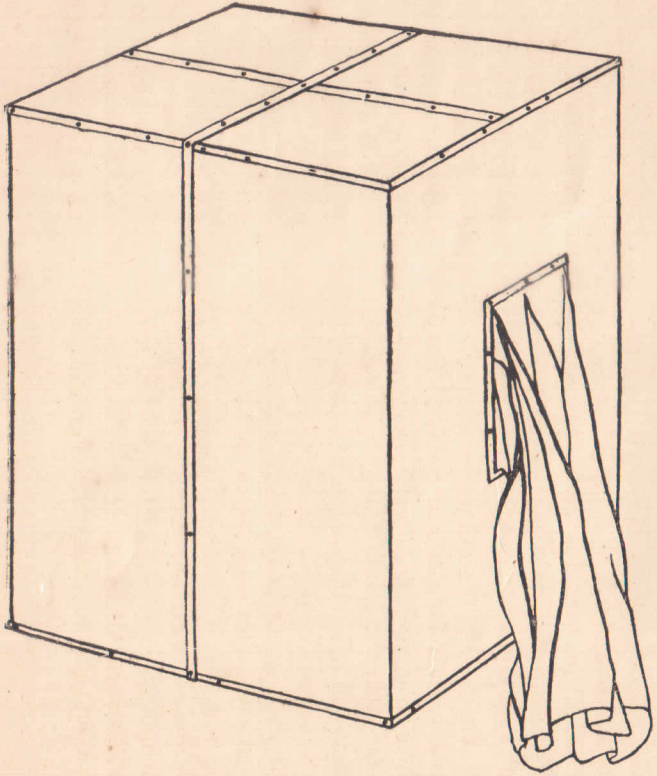


Fig. 1.—Muslin cage, with sleeve at one side.

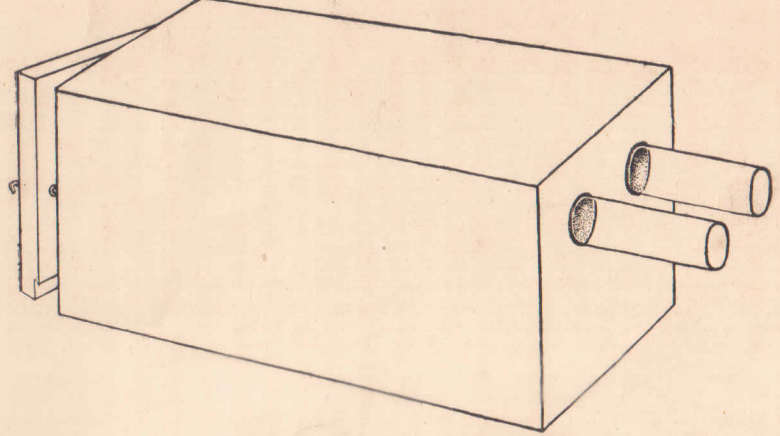


Fig. 2.—Breeding box for parasites.

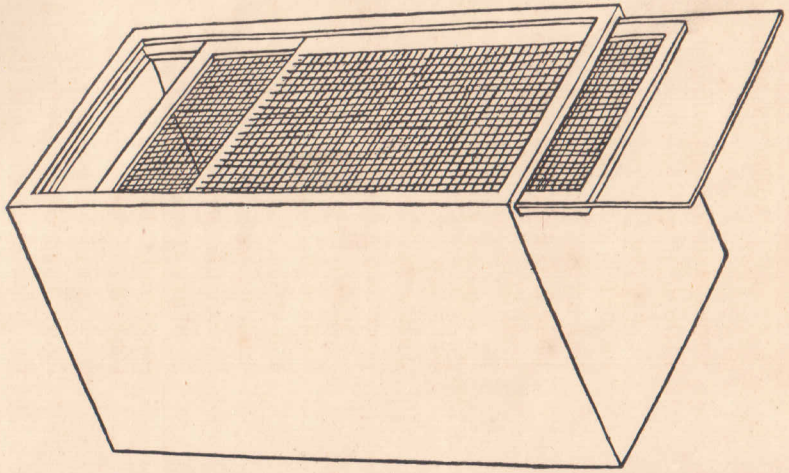


Fig. 3.—Parasite Cage.

care and delicate handling although they are not affected very much by a little dryness or moistness of conditions in which they are kept.

External Parasites on other animals, such as the lice and bugs found on vertebrate and the dipterous parasites of birds and bats, require to be reared on their special hosts as a rule. Fleas, however, do not undergo their transformations on their hosts and are easily reared under dry conditions.

Internal Parasites of vertebrates, such as *Œstrids*, when full-fed larvæ are obtained on expulsion from their hosts, can be reared easily if they are kept in moist earth and not allowed to dry up. The same procedure is followed with Tachinid parasites of insects.

When internal parasites emerge from eggs, larvæ or pupæ which happen to be under rearing in the glass jars, they are easily observed and collected. When perforated covers are used for the jars in which minute parasites are expected the wire gauze of the covers should either be very fine or be protected with silk gauze or muslin.

When it is intended to rear out parasites especially we use the cage shown in Pl. 135, fig. 2. It is made of wood. Parasites appear in the tubes when they can be collected. The door is on the end opposite to that in which tubes are fitted. Another pattern is the one shown in figure 3 and this kind of cage has been largely used for the introduction of the bollworm parasite in the Punjab. It is made of wood and has two covers, one of wire gauze and the other of glass or wood. The glass remains above the wire gauze. When parasites come up through the wire gauze they are visible through the glass. When too much green stuff is placed inside the box, a quantity of moisture collects under the glass. The parasites are caught in the drops of moisture and are drowned. Without the glass cover the box works fairly well when it is intended to let out the parasites, a wooden cover being used in this case.

The leaf-eaters form the most numerous group of those insects which feed upon living plants. Some of them feed openly on leaves, biting them from the top or margin, or gnawing holes in their surface. It is unnecessary to quote examples as this form of feeding is quite common. Some roll individual leaves and feed while living inside the rolled leaves, for instance, *Sylepta* on cotton, *Eublemma* on brinjaare d *Margarodes* (*Glyphodes*) *indica* on cucurbitaceous plants. There vingothers which bind several leaves together and feed similarly while living inside them, for instance, *Chapra mathias* on rice, *Phycita infusella* on cotton and *Eucosma critica* on *Cajanus indicus*. Among the leaf-eaters we can include those which nibble the leaf surface like the *Epilachna* grubs. All these require a supply of fresh leaves. The ideal codition would be to keep them on living plants growing in soil and covered with cages or

on plants growing in pots which can be introduced into breeding cages when necessary. This however is only possible when one deals with a few kinds of insects and with only a few specimens of each kind. Even then some are such voracious eaters, for instance, the Sphingid caterpillars, that it is difficult to keep only a few individuals supplied with sufficient potted plants. Besides it is not always possible to foresee what insects may require to be fed and to have sufficient plants ready for them beforehand. Therefore it is absolutely necessary to use some kind of handy cages in which the insects can be kept confined and fed with leaves. Such cages are essential when we want to study individual larvæ very closely.

Leaf-feeders kept in cages require to be given a constant and regular supply of fresh leaves, which should be fresh and neither dried up nor wet when given. If leaves are of necessity gathered in a wet condition, they are best dried by placing them in the centre of a dry towel or cloth and whirling this around by the corners, so that the moisture is driven out by centrifugal action without bruising the leaves.

Care must also be taken that no predaceous insects or other animals are introduced with the leaves.

When only a few insects are under rearing in one cage, it is well to count them when fresh food is given, to make sure that none are removed and thrown away with the old food when it is removed.

Young caterpillars especially are very delicate animals and should not be handled if it can be avoided. They also require tender leaves of their foodplant as a rule.

Leaf-miners, among which can be included also those which mine under the epidermis of the green bark like that of cotton. For a few examples we can name *Acrocercops*, *Rhynchœnus* and *Eugnamptus* on mango leaves, *Phyllocnistis* on lemon leaves, *Hispa* on rice leaves and *Trachys* on jute leaves. It should be remembered that in the case of all these, as in the case of the majority of miners of this description, the larvæ complete their larval life in the same mine and cannot form a fresh one even when they are provided with suitable leaves. They live inside and feed on moist tissue. Therefore it is essential that when the leaves containing them are plucked from the plants they should be kept moist as long as possible. For this purpose the glass dishes and jars are invaluable. In some cases the use of wet blotting paper is necessary or a layer of moist earth may be placed at the bottom of the cage. There are a few miners which can migrate to fresh leaves and form fresh mines in them, for instance, the caterpillars of *Phthorimæa ergasima* and the grubs of *Platypria andrewesi*. Rearing them is easy, as they can be supplied with fresh leaves as long as necessary.

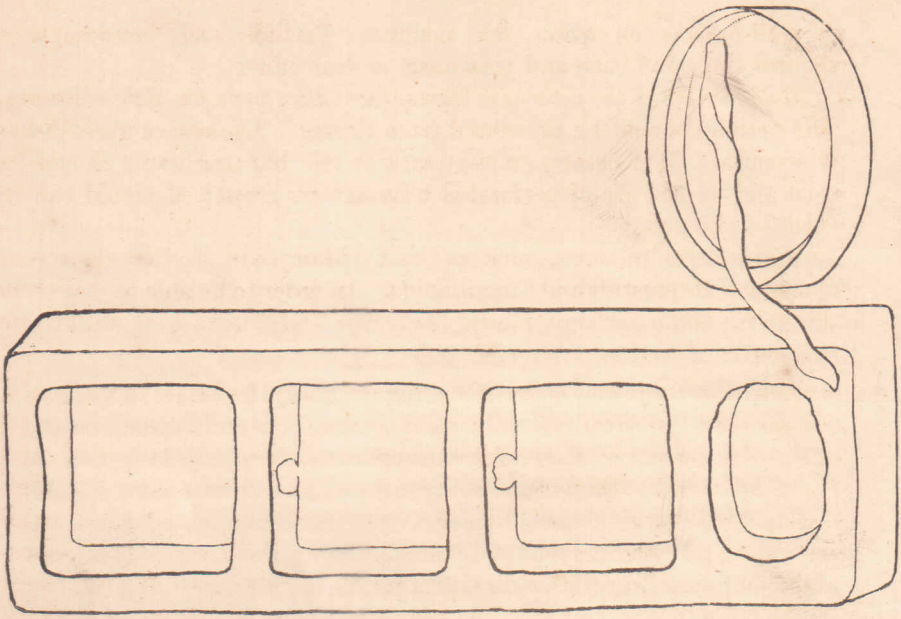


Fig. 2.—Tile cage for Termites.

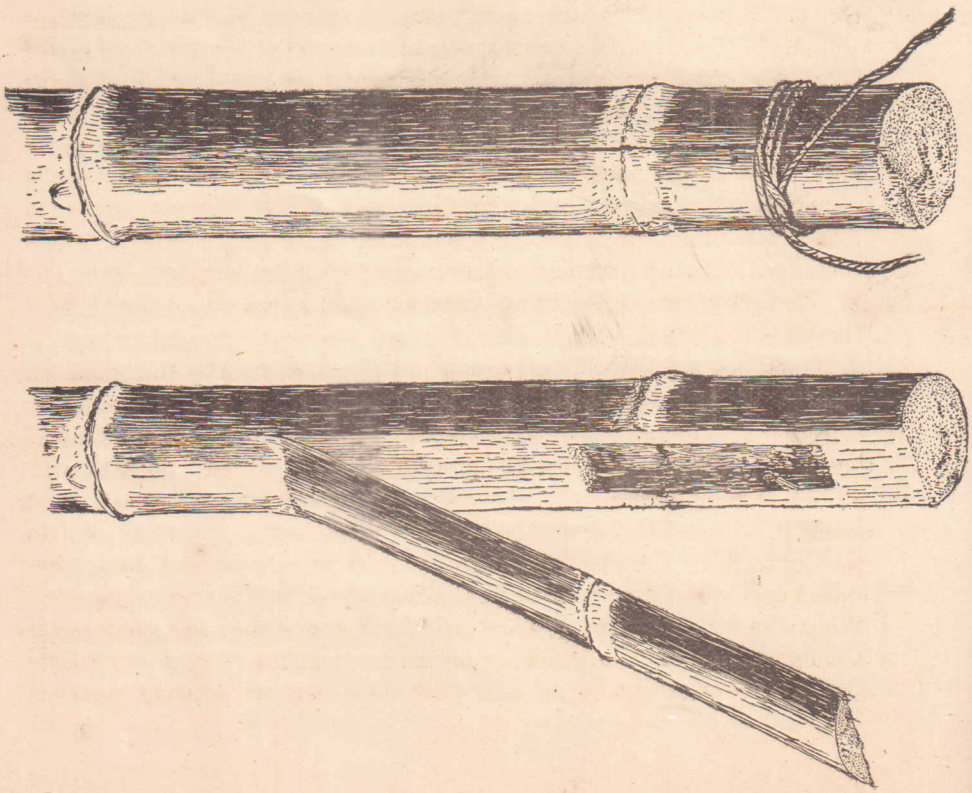


Fig. 1.—Method of feeding borer larvæ.

Gall-formers on leaves, for instance, Psyllids and Cecidomyiads, require the same care and treatment as leaf-miners.

Gall-formers in the petioles of leaves, like *Clitea picta* on *Ægle marmelos*. The petioles should be prevented from drying. The use of glass dishes is essential. If necessary, moist earth or wet blotting paper should be used and by the use of perforated brass covers growth of mould can be entirely checked.

Gall-formers in stems, such as the Cecidomyiads in Cucurbitaceous plants and Buprestids and Curculionids. In order to be able to rear them the galls should be kept moist. Like the leaf-miners they cannot be transferred into fresh stems.

Borers in twigs and green stems, for instance, the larvæ of *Chlumelia transversa* and *Alcides frenatus* in mango twigs, *Chilo* and *Sesamia* in maize, rice and allied plants, *Scirpophaga* in sugarcane, *Nupserha* in soybean and *Phaseolus* stems. Many examples can be quoted from among the Buprestids, Cerambycids, Curculionids, Noctuids, Pyralids and Flies which are among the worst pests of plants. Among them some like *Scirpophaga* and most Buprestids do not fare well if transferred to fresh stems and they are better reared in the stems in which they occur. Of course the stems should be prevented from drying and glass jars are useful for the purpose. The others can easily be transferred into fresh stems and the best method is to bore holes at the ends of the pieces of stems intended to be given as food with the pointed end of a pair of forceps or with a gimlet. The larvæ are put into these holes and they bore in well. In some cases however the larvæ leave these holes and cannot find their way back and in order to make them stay there, the following plan may be adopted. A longitudinal slice is cut but not detached from the stem and a portion of the interior of the stem below this slice is scooped out with a knife to afford enough room for the larva to be put in. The larva is placed there and the slice closed and secured with thread. (Pl. 136, Fig. 1.)

For larger borers in woody stems or dry wood, such as the longicorn grubs we find in mango, orange, jak and many other trees, large pieces of stems should be taken and holes bored in them with augers. The larvæ are put in these holes, the mouths of which are best plugged with a piece of wood or cork. In the case of those which work in fresh moist stems it is desirable to keep the stems moist as long as possible. We do this by keeping the pieces of stems covered with moist saw-dust. Besides keeping the stems moist the sawdust serves another useful purpose. When the larvæ happen to bore out of the stems they find themselves among sawdust and are not at all inconvenienced even if immediate attention is not forthcoming. In some cases they are actually observed

to bore through the layer of sawdust. Apparently the sawdust serves partly as food. These borers are such slow growers that they tax the rearers' patience sometimes. There is hardly a case in which one has to wait for less than a year before the adult is obtained. Two or three years are not uncommon. Examination of the stems in which the borer larvæ are placed should be made with great discretion. Frequent examination causes disturbance which the larvæ cannot endure. Then during examination the stems should be split or opened with the greatest care and patience as the exact whereabouts of the insect is unknown and it is likely to be injured. It may have formed its pupal cell and may be pupating or may have pupated. Disturbance at this time is often injurious and in the majority of cases leads to the death of the insect. Some of the borers in drywood, especially the Buprestids, cannot endure transference and have to be reared in the wood in which they occur.

Root-borers, such as Hepialids, require the same treatment as stem-borers. Among this class may be included borers such as *Cylas formicarius* in sweet potato tubers; such can be reared out easily.

Borers into flower-buds or larvæ which eat petals of flowers, require a supply of fresh flower-buds and flowers and can be reared easily.

Of the *insects affecting fruits*, the fruitfly larvæ require a supply of moist earth to pupate in and, as in the case of all Diptera, the pupæ should be kept moist and not allowed to dry up. A layer of moist earth should be kept at the bottom of the glass jars or troughs and the fruits containing the maggots should be placed on the earth. The maggots when full-fed will go into the earth and pupate there. When the fruits are succulent like pumpkin and give out a large quantity of water on decomposition it is better to use an extra large quantity of dry (not moist) earth. The dry earth absorbs the water and becomes moist. Otherwise the excess of moisture may cause the pupæ to rot. In rearing these flies it may be necessary to dispense with glass or metal covers for the jars and keep them covered with muslin.

Many larvæ bore into fruits for the seeds which they eat. Common examples are *Etiella* boring *Khesari* (*Lathyrus sativus*) and other pods, *Heliothis armigera*, *Exelastis* and *Catochrysops* boring *arhar* pods, and *Virachola* boring pomegranates. Such larvæ require a supply of green pods and fruits and are easily reared. *Bruchids* do not require any fresh food to be supplied and are reared in the pods or rather seeds in which they occur.

Root-eaters, e.g., Melolonthid, Elaterid, Curculionid and Chrysomelid larvæ, live underground and are best kept in glass jars with ample moist earth and provided with roots, principally of grasses. The roots supplied must be fresh.

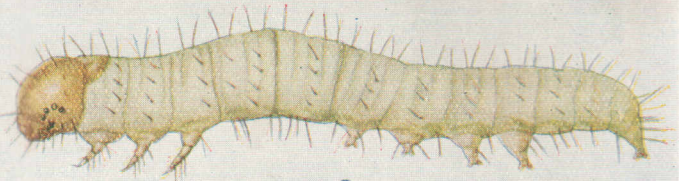
Although called root-eaters the food of many of these insects is not definitely known. Many Melolonthid grubs, for instance those of *Anomala polita*, have been reared wholly on farmyard manure, while others are known definitely to attack living plants, *e.g.*, *Anomala bengalensis* on sugarcane. Probably many of them depend on a variety of food. In the case of caterpillars and termites of course there is no cause for doubt. The food of Tipulids and Asilid larvæ, which are ordinarily taken to be root-eaters, is not definitely known in India. *Gryllotalpa africana* is definitely known to be both herbivorous and predacious. Of the Elaterid larvæ some are certainly predaceous, *e.g.*, *Agrypnus fuscipes*, others may be both predaceous and herbivorous.

Whatever their food the larvæ which live underground in nature must be kept in moist earth, and as the larval life of most of them is very long, it is an advantage if the earth in the rearing cage can be kept moist for long periods without being required to be changed. Numerous Melolonthid grubs are reared at Pusa every year. They live for about a year and are kept in glass jars and dishes and, if glass covers are used, it becomes hardly necessary to change the earth even once. Metal covers are unsuitable for the purpose as they allow evaporation to go on. When it is not necessary to change the earth there is very little disturbance of the insects.

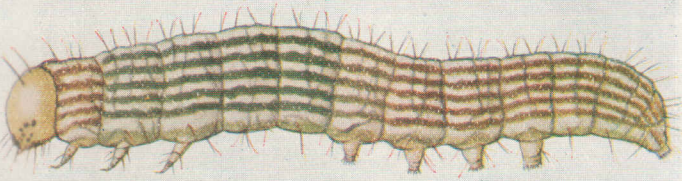
As the food of most of these underground larvæ is unknown, attempts to rear them from their young stage frequently fail. It is therefore advisable to collect the larvæ in the advanced state of growth and then their rearing is almost always successful. When the food is known and a supply of it can be kept up, they can be reared without much difficulty provided the earth in which they are made to live remains always moist. One *Agrypnus fuscipes* larva lived in the Insectary for over two years. It was fed with caterpillars and Melolonthid and Scarabæid grubs. Similarly *Gryllotalpa africana* was reared from the egg stage, being fed with live fly maggots only for about 5½ months.

Sucking insects, which live by sucking the sap from living plants—the plant—sucking Heteroptera, Homoptera and Phytophthires—require living plants. We usually grow plants in pots and, when convenient, keep the potted plants on which the insects feed in zinc breeding cages (Pl. 133, fig. 1) or cover the plants with muslin or silk gauze. Some of them are however amenable to feeding in glass jars with portions of their foodplants from which they can obtain enough juice. *Leptocorisa varicornis* has been reared on ears of *Setaria italica*, *Riptortus* on pods of *Cajanus indicus*, *Nezara viridula* on pods of *Cajanus indicus* and *Phaseolus radiatus* and *Aspongopus* on succulent stems of pumpkin. When they get abundant juice they can be reared in this manner. In fact, some of

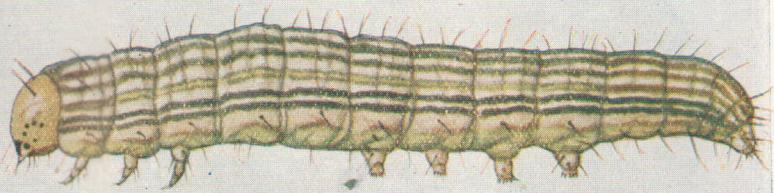
1



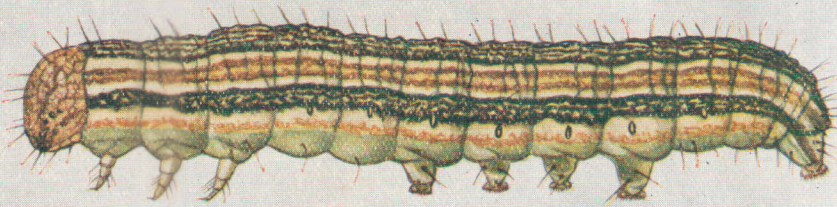
2



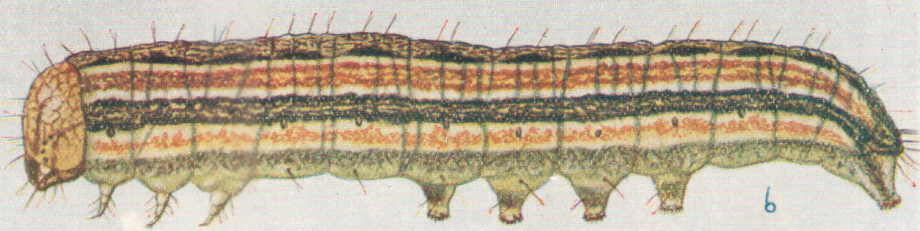
3



4



5



6

CIRPHIS ALBISTIGMA.

them in nature have adapted themselves to this habit, for instance, mealy-bugs (*Pseudococcus nipæ*) and Tingid bugs (*Recaredus* sp.) on seed potatoes in store.

Inducing oviposition. In order to observe and note details of life-history it is often necessary to rear out adults or collect them from the fields and make them lay eggs in confinement. All insects will not oviposit easily under such conditions. They require the conditions in which they lay eggs in nature or at least conditions as far as possible similar. Almost all plant-feeding insects require living plants in order to oviposit. Sometimes when gravid females are obtained from outside they deposit eggs even when kept confined in a small pill-box, because then egg-laying is a necessity with them. Special means have to be adopted to get eggs from different insects. It is not possible to give here our whole experience. We can only refer to a few cases.

It is generally difficult to induce butterflies to oviposit in confinement. They require living plants and a large amount of space to fly about in and may have to be fed with sugar or honey syrup. We keep them in the side-cages of the Insectary which give them sufficient room to fly about. Potted plants are supplied. Feeding is done according to the following method. The syrup is placed in a glass crucible or watch-glass. The butterfly is held in one hand between the thumb and forefinger with the wings turned over its back and with a pin in the other hand the proboscis is stretched out and its end dipped in the syrup.

For moths the large-sized zinc breeding cages (Pl. 133, fig. 1) are used, potted plants being placed in them when necessary. These cages also serve for bugs, sawflies and many kinds of beetles. Ant-lions can be made to oviposit in these cages on a layer of fine dry sand placed on the bottom.

For grasshoppers we use the side-cages of the Insectary. Into one of these cages one pair of *Hieroglyphus banian* was introduced in 1905. Since then we have been carrying on the progeny of this pair. Every year young nymphs hatch out about June. They are fed and develop, deposit eggs in the earth of the cage in October and November and then die. The eggs in due course hatch about June again.

In order to be able to observe the details of oviposition in the case of grasshoppers and other insects which thrust their eggs into the ground, they should be placed in a cage with four glass sides and provided on the bottom with a block of wood two or three inches high and in size about half-an-inch less in breadth and width than the internal breadth and width of the cage. This wooden block is covered with a very thin layer of earth which however fills the quarter-inch space left all around between the block and the glass sides of the cage. The grasshoppers,

finding insufficient depth of soil on top of the block for oviposition, are then forced to oviposit against the glass through which their motions may be watched. The space between glass and wooden block may be varied with the size of the grasshopper under rearing.

For *Heliocopris bucephalus* a small cage is unsuitable. The beetles were therefore placed in a large side cage in the Insectary. They at once bored into the earth. Fresh cowdung was placed on the surface of the earth and was taken down by the beetles through tortuous galleries up to a depth of about 4 feet. Oviposition was successful and a brood was reared out.

It is easy to get soil-living termites to establish colonies in glass jars. The jars are filled with moist earth which is somewhat pressed down and an artificial hole is made in the earth by forcing a pencil or stick into it. From among the winged termites which appear at the time of their annual flight a pair, consisting of a male and a female, is picked out and placed in this hole. Very soon they lay eggs and workers and soldiers appear in due course and are observed to form tunnels. Many colonies of *Odontotermes assmuthi* were established in this manner in the course of the last five years. In the jars the development of the colonies cannot be properly traced. For this purpose the tile cage illustrated in Pl. 136, fig. 2 was devised. It was made by a local potter. It has three chambers with two partition walls in the middle. But the chambers communicate with one another by means of holes in the partition walls. Besides these chambers there is a cavity at one end meant to serve as a reservoir for water. The idea was that the water kept in this reservoir would slowly soak and keep the tile moist. In actual practice however it was found that the water from this reservoir soaked so rapidly and so much that the chambers became too damp for the termites. Therefore water is kept in a separate vessel and a wetted wick of cotton lint is used so that one end of the wick is dipped in the water and the other end rests on the tile. By this means just sufficient water is soaked up by the tile to keep it moist. The face of the tile is well smoothed by being rubbed on a flat stone. The chambers are covered by glass plates through which the insects inside are visible. In order to produce darkness in the chambers, on top of the glass plates are placed other glass plates on which black paper has been pasted. When it is necessary to observe the insects the upper plates are lifted up. A pair of the winged termites, usually those which have shed their wings, are placed in one chamber in the tile and are allowed to occupy whichever chamber they prefer. The majority of those tried established colonies in the first chamber, *i.e.*, the one next to the source of water and none selected the third chamber. Colonies of *Odontotermes assmuthi* have lived in these tiled cages for about

four months and have then dwindled and died. Some of the colonies in glass jars were buried underground in the compound inside the jars; one of these lived for a year. The tile cages we use measure about 12 inches in length and about 4 inches in breadth. The thickness from face to back is about one inch. The inside dimensions of the chambers are about $3 \times 3 \times \frac{1}{2}$ inches.

Colonies of *Microtermes obesi* were similarly established in glass jars and also in the tile cages. But they seemed to be more delicate than *Odontotermes assumuthi* and died quickly.

Some general hints on rearing. It is advisable to examine the cages every day in the morning or better still, both morning and evening and take out the insects which have emerged. Butterflies and moths are better taken out as soon as their wings have hardened or they may spoil the scales on the wings by fluttering in the cage. Flies are better left for a day or two; if killed too soon their wings collapse and shrivel. Beetles should be left for two or three days or their colour does not develop properly. Bugs and grasshoppers should also be left in the cages for two or three days to allow them to harden their wings and develop colour.

In the case of large specimens, for instance, Sphingid moths, Saturniad moths, larger butterflies, etc., it may be necessary to transfer the pupæ from small rearing cages to zinc breeding cages so that the imagines on emergence may crawl up the wire gauze wall and hang and develop their wings properly. Otherwise the result is a specimen with crumpled undeveloped wings. If the rearing cage be large a few long sticks stuck into the earth or stood against the walls may serve the purpose.

Cannibals. The rearer will find by experience that some insects, which are normally plant-feeders, develop into voracious cannibals when kept in close proximity to their fellows under conditions of confinement. If, on counting them, caterpillars are found to have disappeared without visible reason, cannibalism may reasonably be suspected. Such larvæ must of course be reared separately.

Records. A very important part of rearing is the proper recording of full descriptions and accounts of all the stages of all insects under rearing. These may either be Cage-slips kept on separate uniformly-sized sheets of paper placed under, or at least with, each cage or may be kept in a register or note-book. In any case, each separate lot of insects reared should be provided with a separate number corresponding to the Cage-slip or entry n the register, and the reared specimens should have this number entered on their labels, so that, in after time, there is no possible doubt as to the actual specimens to which the records refer.

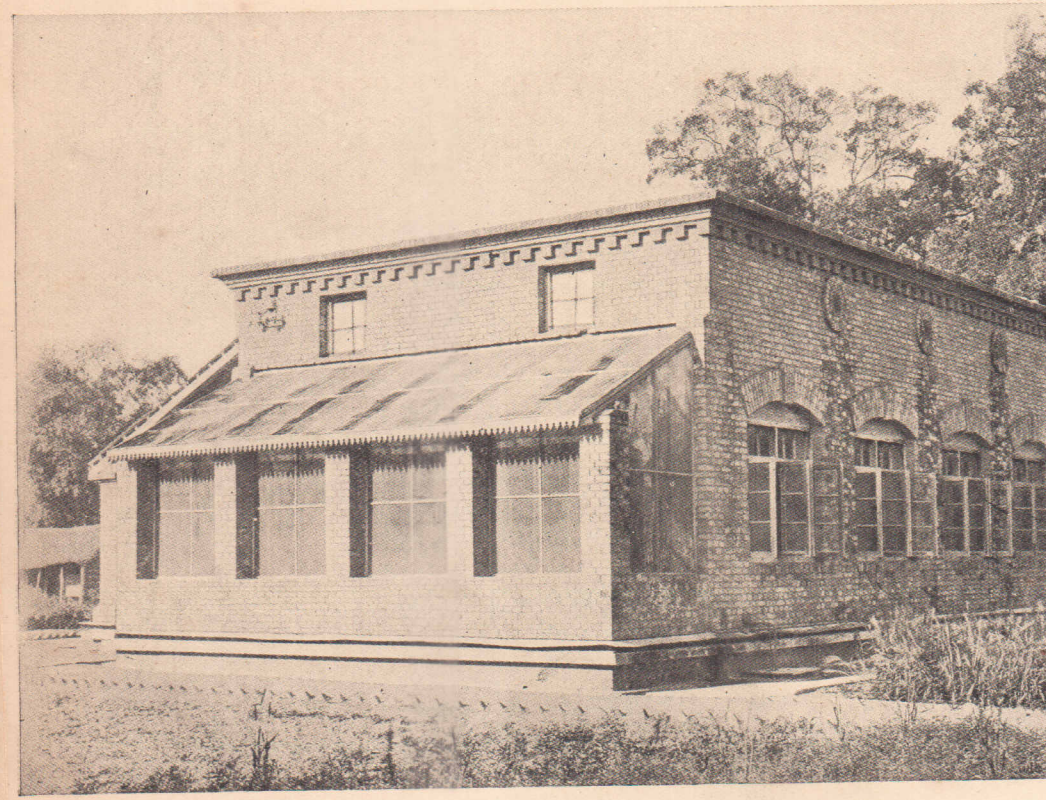


Fig. 1.—The Pusa Insectary.

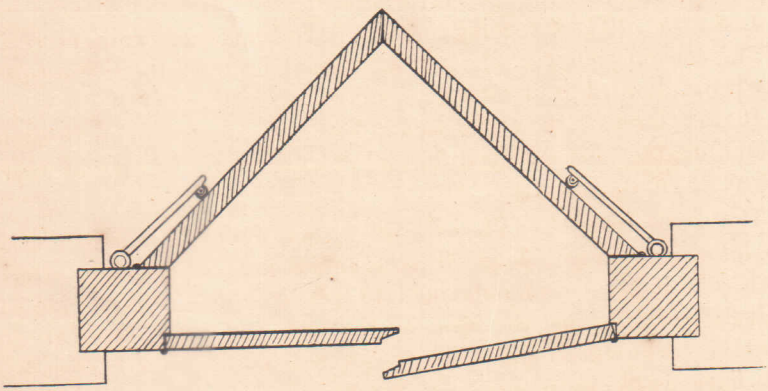


Fig. 2.—Details of double door to Insectary.

No time or trouble that can be taken to make these records complete and accurate in all respects can possibly be wasted.

If drawings of the various stages, and of any details of them, can be made, so much the better; and all such drawings also should be fully identified with the number of the Cage-slip or entry in the register.

Preservation of Early Stages. Another important point in rearing is the preservation of material of the early stages. Caterpillars may be blown and most other larvæ preserved in spirit. Empty pupa-cases and cocoons should be preserved pinned with the individual specimens which have emerged from them. Pupæ, even of the same species, often vary considerably in the two sexes and therefore it is important to see that the pupal shell of each *individual* imago is correctly paired off with it. How often one sees series of bred specimens in collections and how seldom are they accompanied with even their empty pupa-cases. Yet it is certain that a close study of pupal structure will often throw very valuable light on the affinities of the insects concerned; and, to carry out work on these lines in India, it is essential to preserve all the material possible in order that it may be available for study.

Quality and Quantity. One advantage of rearing insects is the obtaining of perfect specimens of the adults for the collection. Another advantage, which is often lost sight of in India, is the ease with which not only good but long series of an insect may be obtained. Especially when an unknown insect, found doing damage in its larval stage, is under rearing, endeavour should be made to rear and preserve a long series of adults in order that amply sufficient material may be available for determination of the species concerned.

Insectaries. The foregoing remarks have been made more especially for the general collector who has no special facilities for rearing other than those afforded by an ordinary room or verandah.

It may, however, be useful to add here a description of an Insectary, or building specially designed for and devoted to the rearing of insects, such as we have at Pusa.

The Pusa Insectary (Pl. 137, fig. 1) is a masonry building having one large hall 40 feet long, 24 feet broad and 16 feet high. On the south side it has a verandah about 40 feet long and 10 feet wide with a tiled roof. Against the walls on the east and west there are four cages on each side. These side cages measure 6 feet $\times$ 5 feet each and have brick walls up to a height of about $5\frac{1}{2}$ feet from the bottom. Above the brick walls right up to the roof wire gauze is fitted into wooden frames and encloses the cage completely. The roof slopes from the wall of the main building outwards and is made of glass which is protected from hail by wire-netting over it. Each cage

is filled with earth up to the height of the brick walls. The earth is watered as necessary and remains moist throughout the year. At first only two of these cages had cemented bottoms. Termites, crickets and even beetles often appeared in the other cages which had no cemented bottom and therefore communicated with the soil below. All the cages have now been provided with cemented bottoms. They do not communicate with one another but each has a panelled door fitted with glass panes and opening into the hall.

Insects are sent in to Pusa from various places in India and as some of them may not occur in the neighbourhood of Pusa or in Northern India, the Pusa Insectary, in which they are intended to be reared, is built on a plan which prevents their escape from confinement even if they escape from the rearing cages. The doors and windows are protected with wire-screen having about 12 meshes to the inch. This is not fine enough for very small insects. But no case of introduction of an undesirable insect into the locality has happened during the last fourteen years. With the same object in view the outer doors are provided with double flaps, the outer pair of which is of wire gauze (Pl. 137, Fig. 2); one pair of these flaps can be shut before the other pair is opened; thus the entrance of any insect from outside or the escape of any from inside can be checked. This is satisfactory so far as flying insects or large creeping ones are concerned but is no protection against small creeping ones. In fact, ants are a trouble throughout the hot weather and the rains. In order to prevent them an ant-channel of re-inforced concrete was added all round the wall at a height of about a foot from the ground. The channel is about one inch deep and is kept filled with water mixed with phenyle or crude oil emulsion. In order to prevent leaves and grasses being blown into the channel and affording bridges for ants to cross over it was necessary to have a shade of galvanized zinc sheet (see Pl. 137, fig. 1) over it. The ant-channel works satisfactorily. But as the floor was of bricks set on edge and not of concrete, ants were able to come up anywhere in the floor from below the foundation. In order to prevent this the floor has recently been concreted. Still, however, we have not been able to get rid of ants altogether. The walls, not being plastered from outside, ants have found enough room to establish nests in them.

When future insectaries are built, in order to make them really ant-proof the following arrangements illustrated in Pl. 138, Fig. 1 might be tried. All round the building at about the ground level there should be a cemented *pucca* drain which may be a shallow one. This will prevent water settling at the foundation and also ants from establishing nests

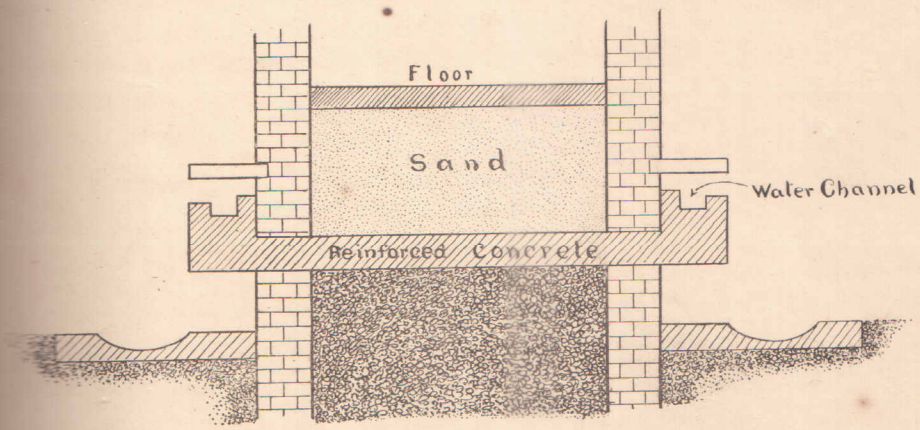


Fig. 1.—Plan for foundation of an Insectary in order to make it ant-proof.

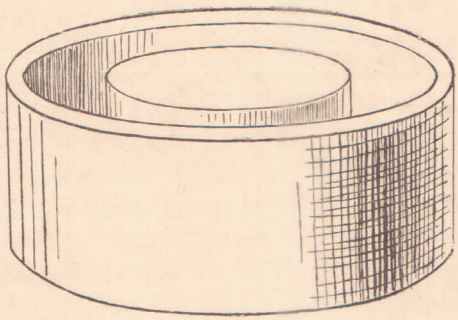


Fig. 2.—Ant-preventing stand.

there. At a height of about six inches from the ground-level the entire floor including the walls should have in one complete sheet a layer of reinforced concrete not less than two inches thick. This will prevent termites as well as ants from coming up from below. Above the layer of cement concrete all round the wall on the outside there should be an ant-channel of reinforced concrete, the channel being about $1\frac{1}{2}$ inches deep and about 2 inches wide. About 2 inches above the channel a brick should project out of the wall and act as a shade over the channel. The walls of the insectary should be plastered both inside and outside, thus leaving no room for flying queen ants to establish nests in them.

The plinth of the building may be about 3 feet from the ground-level. The floor should be cemented. The space between the floor and the layer of concrete below may be filled with dry sand. This will afford additional protection against ants and termites and make the floor proof against damp.

Inside the building the furniture should be plain tables and shelves for rearing cages, etc. It is desirable to have removable tables and shelves which can be taken out and cleaned if silver fish get access and prove troublesome. If water-troughs, etc., are required, they should be of reinforced concrete or at least with cemented walls. If brick walls are left unplastered and with *surki* or cement pointing dust settles in the chinks and converts them into favourite breeding places of *Macrœola inquisitrix*. Chinks in the walls and tables afford hiding places for the silver fish also. Therefore they should be avoided as much as possible.

Ants and silver fish are really pests of the insectary. The former get into rearing cages and attack the insects. The latter nibble away dates and records from the cage-slips. Therefore it is necessary to keep both away from the insectary as far as possible.

As regards the structure of the building, there should be large windows and as many of them as possible. They should all be protected with wire gauze, say of not less than 16 meshes to the inch and provided with flaps on the outside which can be shut when necessary, for instance, against driving rain. When ample ventilation is ensured by the provision of as many large windows as possible—a condition which is present in the Pusa insectary—the temperature inside the insectary does not vary to a great extent from that prevailing outside. Therefore the insects kept in the insectary are not affected to a great extent by the artificial conditions incident to rearing indoors. When this condition is secured the observations recorded in the insectary approximate very closely to those recorded outside. This has been verified in the case of numerous hibernating and æstivating insects and all stages of them, *viz.*, eggs,

larvæ, pupæ and adults, which have been kept under observation both in the insectary and outside in the fields. In the Plains of India it is not necessary to have the conditions of a green-house or glass-house for rearing insects. Nor should there be any discrepancy between observations carried on in the insectary and those under actual field conditions.

When however no separate insectary is built it is preferable to carry on rearing in the verandah of a house. The verandah can be enclosed with wire gauze and in order to prevent ants the legs of rearing tables can be placed on ant-proof stands as shown in Pl. 138, fig. 2. The stands may be of wood or stone and the channels in them should be kept filled with water or phenyle water to prevent ants crossing the water or mosquitos breeding in it.

Publications of the Imperial Department of Agriculture in India.

To be had from :—

The Office of the Agricultural Adviser to the Government of India, Pusa, Bihar, and from the following Agents :—

1. Thacker, Spink & Co., Calcutta.
2. W. Newman & Co., Calcutta.
3. Rai M. C. Sarkar Bahadur & Sons, Calcutta.
4. Higginbothams, Ltd., Madras.
5. Thompson & Co., Madras.
6. D. B. Taraporevala, Sons & Co., Bombay.
7. Thacker & Co., Ltd., Bombay.
8. Sunder Pandurang, Bombay.
9. Rai Sahib M. Gulab Singh & Sons, Lahore.
10. Manager, Educational Book Depôt, Nagpur.

A complete list of the publications of the Imperial Department of Agriculture in India can be obtained on application from the Agricultural Adviser to the Government of India, Pusa, Bihar, or from any of the above mentioned agents.

These publications are :—

1. The *Agricultural Journal of India.* A Journal dealing with subjects connected with agricultural economics, field and garden crops, economic plants and fruits, soils, manures, methods of cultivation, irrigation, climatic conditions, insect pests, fungus diseases, co-operative credit, agricultural cattle, farm implements, and other agricultural matters in India. Illustrations, including coloured plates, form a prominent feature of the Journal. It is edited by the Agricultural Adviser to the Government of India, and is issued once every two months or six times a year. *Annual Subscription*, Rs. 6 or 9*s.* 6*d.*, including postage. Single copy, R. 1-8 or 2*s.*
2. Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Imperial Cotton Specialist).
3. Annual Report on the Progress of Agriculture in India.
4. Proceedings of the Board of Agriculture in India.
5. Proceedings of Sectional Meetings of the Board of Agriculture.
6. Memoirs of the Imperial Department of Agriculture in India :

   (*a*) Botanical Series.
   (*b*) Chemical Series.
   (*c*) Entomological Series.
   (*d*) Bacteriological Series.
   (*e*) Veterinary Series.

7. Bulletins issued by the Agricultural Research Institute, Pusa.
8. Books.

The following are the publications of the last two years :—

Scientific Reports of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist), for the year 1918-19. Price, R. 1-4 or 2*s.*

Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Secretary, Sugar Bureau), for the year 1919-20. Price, R. 1.

Report on the Progress of Agriculture in India for the year 1917-18. Price, R. 1-8 or 2*s.* 3*d.*

Report on the Progress of Agriculture in India for the year 1918-19. Price, R. 1-8 or 2*s.* 3*d.*

Proceedings of the Board of Agriculture in India, held at Pusa on the 1st December, 1919, and following days (with Appendices). Price, As. 12 or 1*s.* 3*d.*

Proceedings of the Second Meeting of Mycological Workers in India, held at Pusa on the 20th February, 1919, and following days. Price, As. 11 or 1*s.*

Proceedings of the First Meeting of Agricultural Chemists and Bacteriologists, held at Pusa on 24th February, 1919, and the following days. Price, R. 1 or 1*s.* 6*d.*

Proceedings of the First Meeting of Veterinary Officers in India, held at Lahore on the 24th March, 1919, and following days (with Appendices). Price, As. 8 or 9*d.*

Proceedings of the Third Entomological Meeting, held at Pusa in February, 1919. Price, Rs. 17-8.

EXPLANATION OF PLATE 16.

Cirphis albistigma.

Fig. 1. Pupa, magnified (×5).
Fig. 2. Moth, male, magnified (×2½).
Fig. 3. Moth, female, magnified (×2½).

MEMO

letin No. 104 1921

Agricultural Research Institute, Pusa

The Rice Leaf-hoppers

BY

C. S. MISRA, B.A.,

First Assistant to the Imperial Entomologist

(Reprinted from the Proceedings of the Third Entomological Meeting.)

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1921

Price As. 6.

Edited by

The Council of the Pusa Agricultural Research Institute, which is not, as a body, responsible for the opinions expressed in the Bulletin.

Bulletin No. 104 1921

Agricultural Research Institute, Pusa

The Rice Leaf-hoppers

BY

C. S. MISRA, B.A.,

First Assistant to the Imperial Entomologist

(Reprinted from the Proceedings of the Third Entomological Meeting.)

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1921

Agents for the Sale of Books Published by the Superintendent of Government Printing, India, Calcutta.

IN EUROPE.

Constable & Co., 10, Orange Street, Leicester Square, London, W.C.

Kegan Paul, Trench, Trübner & Co., 68-74, Carter Lane, E.C., and 25, Museum Street, London, W.C.

Bernard Quaritch, 11, Grafton Street, New Bond Street, London, W.

P. S. King & Sons, 2 & 4, Great Smith Street, Westminster, London, S.W.

H. S. King & Co., 65, Cornhill, E.C., and 9, Pall Mall, London, W.

Grindlay & Co., 54, Parliament Street, London, S.W.

Luzac & Co., 46, Great Russell Street, London, W.C.

W. Thacker & Co., 2, Creed Lane, London, E.C.

T. Fisher Unwin, Ltd., 1, Adelphi Terrace, London, W.C.

Wm. Wesley & Son, 28, Essex Street, Strand, London.

B. H. Blackwell, 50 & 51, Broad Street, Oxford.

Deighton Bell & Co., Ltd., Cambridge.

Oliver and Boyd, Tweeddale Court, Edinburgh.

E. Ponsonby, Ltd., 116, Grafton Street, Dublin.

Ernest Leroux, 28, Rue Bonaparte, Paris.

Martinus Nijhoff, The Hague, Holland.

IN INDIA AND CEYLON.

Thacker, Spink & Co., Calcutta and Simla.

Newman & Co., Calcutta.

R. Cambray & Co., Calcutta.

S. K. Lahiri & Co., Calcutta.

B. Banerjee & Co., Calcutta.

The Indian School Supply Depôt, 309, Bow Bazar Street, Calcutta, and 226, Newabpur, Dacca.

Butterworth & Co. (India), Ltd., Calcutta.

Rai M. C. Sarcar Bahadur & Sons, 19/2A, Harrison Road, Calcutta.

The Weldon Library, 57, Park Street, Calcutta.

Standard Literature Co., Ltd., Calcutta.

Lalchand & Sons, Calcutta.

Association Press, Calcutta.

Higginbotham & Co., Madras.

V. Kalyanarama Iyer & Co., Madras.

G. A. Natesan & Co., Madras.

S. Murthy & Co., Madras.

Thompson & Co., Madras.

Temple & Co., Madras.

P. R. Rama Iyer & Co., Madras.

Vas & Co., Madras.

M. R. Ry. E. M. Gopalakrishna Kone, Madura.

Thacker & Co., Ltd., Bombay.

A. J. Combridge & Co., Bombay.

D. B. Taraporevala, Sons & Co., Bombay.

Radhabai Atmaram Sagoon, Bombay.

Sunder Pandurang, Bombay.

Gopal Narayan & Co., Bombay.

Ram Chandra Govind & Son, Kalbadevi, Bombay.

Proprietor, New Kitabkhana, Poona.

The Standard Bookstall, Karachi.

Mangaldas Harkisan Das, Surat.

Karsandas Narandas & Sons, Surat.

A. H. Wheeler & Co., Allahabad, Calcutta and Bombay.

N. B. Mathur, Supt., Nazir Kanun Hind Press, Allahabad.

Munshi Seeta Ram, Managing Proprietor, Indian Army Book Depot, Juhi, Cawnpore.

Rai Sahib M. Gulab Singh & Sons, Mufid-i-Am Press, Lahore and Allababad.

Rama Krishna & Sons, Lahore.

Supt., American Baptist Mission Press, Rangoon.

Manager the "Hitavada" Nagpur.

S. C. Talukdar, Proprietor, Students and Company, Cooch Behar.

A. M. & J. Ferguson, Ceylon.

Manager, Educational Book Depôts, Nagpur and Jubbulpore.*

Manager of the Imperial Book Depôt, 63, Chandney Chauk Street, Delhi.*

Manager, "The Agra Medical Hall and Co-operative Association, Ltd." (Successors to A. John & Co., Agra).*

Supt., Basel Mission Book and Tract Depository, Mangalore.*

P. Varadachary & Co., Madras.*

H. Liddel, Printer, etc., 7, South Road, Allahabad.*

D. C. Anand & Sons, Peshawar.*

Ram Dayal Agarwala, 184, Katra, Allahabad.*

Manager, Newal Kishore Press, Lucknow.*

* Agents for the Sale of Legislative Department publications only.

16.—THE RICE LEAF-HOPPERS.

By C. S. Misra, B.A., *First Assistant to the Imperial Entomologist.*

(*Nephotettix bipunctatus*, Fabr. and *N. apicalis*, Motsch.)

The rice leaf-hoppers were reported for the first time damaging rice in the Sambhalpur District, Bihar and Orissa, in 1910. But the hoppers appeared late in the season and consequently slight or no damage was done. They again appeared in 1913 though late in the season and did some damage to the standing crop of rice. The same year they were also reported from Champhai in the Lushai Hills. Mr. J. Hezlett, I.C.S., Superintendent, Lushai Hills, Aijal, wrote on the 4th December 1913 :—

"The flat areas under wet rice cultivation are small and are surrounded by miles of jungle. The insect is well known to the Lushai

and frequently does some damage, but for the first time this year the damage done by it has become serious."

In the Chhattisgarh Division of the Central Provinces the pests were noticed for the first time in 1913 when they appeared late in the season and did some damage to the standing crop of rice. The following year, *i.e.*, 1914, they appeared early and over a much larger area. They did considerable damage to the paddy crop in the Bilaspur and the Raipur Districts of the Central Provinces. The damage done by the hoppers was so serious that the Commissioner of the Division, Mr. H. M. Laurie, I.C.S., wrote :—

" I have been touring in the Mungali Tahsil of the Bilaspur District and I find much complaint of havoc caused in respect to the heavier kinds of rice by the insect '*Maho*' or '*Mahor*' concerning which you have already made some inquiries. The Deputy Commissioner does not think that the damage in the Mungali Tahsil has in any village exceeded four annas, but I am not quite sure about this. I am inclined to think that in some villages in which '*Mai*' or '*Garhuna*' *Dhan* constituted the bulk of the rice sown the damage may have arisen to eight annas, or in some cases even more. A loss of four or six annas in these kinds of *Dhan* will, according to my belief, be found to be a matter of fairly common occurrence even in the Mungali *Tahsil*. The damage done in the Janjgir *Tahsil* is said to be greater than in Mungali. There is complete unanimity of opinion that this pest is absolutely new in the experience of the Chhattisgarhi cultivators. Not even the oldest inhabitant has seen anything like it before....."

In order to get an idea of the damage done by the hoppers in one single year one had to visit the localities and he would have been struck with the havoc caused by the leaf-hoppers. Not only was there no grain but the fields were left unharvested, as they were not worth doing so. By the attack of the hoppers the straw had become insipid and rancid and as such was not eaten by the cattle which were in bad condition. It was fortunate that the pests broke out in a mild form during the following year (1915) otherwise the condition of the people as well as the cattle would have been very miserable. In this connection Mr. D. Clouston, Deputy Director of Agriculture, Southern and Eastern Circle, Central Provinces, wrote on the 16th June 1915 :—

".....it appears to me, however, that in the event of the pest doing as much damage as it did last year, it would be highly advisable to consider whether it is not necessary to appoint a larger entomological staff for the pioneer work. Even if the pest should fail to spread beyond the confines of Chhattisgarh, we still have in that Division alone

nearly three million acres of rice. If we allow only 10 per cent. of the area being affected, we would still have 300,000 acres to deal with."

The total area under rice in the Chhattisgarh Division of the Central Provinces is 3,315,484 acres. Calculating a loss of six annas in the rupee for the badly infested sub-divisions during 1914, the total loss comes to 14 and a half million rupees on the basis of 548 lb. cleaned rice per acre at Rs. 3-1-0, the wholesale price. This enormous loss represents the destructiveness of the hoppers for one season only, and it is unthinkable what the loss would have been, had the pests overrun the paddy crop for a series of years. This also brings into prominence the case of an insect which is not heard of as a pest in the beginning, suddenly it springs into prominence, does considerable damage for a series of years and again sinks into insignificance. The causes which operated specifically in this instance are not well understood up to the present, and the details incorporated regarding the life-history, destructiveness, alternative foodplants, parasites, predators, and preventive and remedial measures elsewhere represent two years' work against the hoppers. But as far as is known the parasites and predators were not so abundant during the seasons when the hoppers were specially abundant, as to warrant the conclusion that they were materially effectual in the destruction and subsequent disappearance of the pests. It may be possible that in subsequent years 1916-18 they have appeared in numbers just at the time when the hoppers were developing and thus circumvented their increase. But in the absence of definite observations or data to substantiate the above conclusion, nothing definite could be put forward to explain satisfactorily the non-appearance of the pests during the years 1916-17 and 1918. That the climatic conditions play no mean part in circumventing or diminishing the numbers of pests requires no explanation, but a critical study of the meteorological data for the years during which the pests overran the paddy crop and damaged it considerably and the subsequent years when they did not appear in numbers does not yield sufficiently convincing facts to explain the abnormal appearance of the pests.

In 1915 the hoppers appeared late and in small numbers and in consequence no serious damage was done. These were preceded by an unexpected outbreak of *Hieroglyphus banian*, and the three Delphacid leaf-hoppers, *Sogata pusana*, Dist., *Sogata distincta*, Dist., and *Sogata pallescens*, Dist. These latter were mistaken for the leaf-hoppers and the measures recommended in the previous year against *N. bipunctatus* and *N. apicalis* were promptly put in operation, with the result that no tangible results were achieved. It was no wonder that the recommendations should have borne no fruit as the two pests differ profoundly in

habits. The rice leaf-hoppers are attracted to light whilst the Delphacid leaf-hoppers are not. The Delphacid leaf-hoppers develop fast in a damp and moist atmosphere whilst the rice leaf-hoppers require hot sunny days to reach their maximum development. The Delphacid leaf-hoppers, like the rice leaf-hoppers, lay their eggs in the issues of leaves. The nymphs on hatching out remain on the leaves sucking the juice and exuding the honey-dew which accumulates on the lower leaves. The nymphs as well as the adults are extremely agile and with the least disturbance jump off from plant to plant. With the break in the rains in the middle of September 1915, the Delphacid leaf-hoppers perished in hordes and were largely parasitized by a Dryinid. Innumerable nymphs of the Delphacid leaf-hoppers could be seen with dark-castaneous to blackish ovoid sacs either on the meso-and meta-pleural regions or on the penultimate segment laterally. When parasitized by the Dryinid, the nymphs became sluggish in their movements. They were then to be seen either moving about awkwardly on the leaves or jumping off short distances only. When the parasitic grub becomes full-led, the sac containing it dehisces longitudinally and a whitish legless Dryinid grub comes out. It moves about a little or rests on the spot it came out of the sac and begins spinning a thin hammock-shaped cocoon within which it spins another, ovoid in shape and consisting of firmer texture than the outer one. From such a cocoon the adult Dryinid comes out by biting a circular hole with its strong mandibles. On emergence the adult is very active and flits about the fields infested by the Delphacid leaf-hoppers. In fact the Dryinid was responsible for the destruction of a large number of Delphacid leaf-hopper nymphs. The nymphs seemed to be the special victims as in no case could I see a parasitized adult. An examination of a large number of paddy fields in the infested area in the Bilaspur District of the Chhattisgarh Division, Central Provinces, showed that a large number of pupæ of the parasite were to be seen on the infested plants. With the disappearance of the Delphacid leaf-hoppers the Dryinid parasite also disappeared. The two pests preceding the leaf-hoppers were destroyed to a large extent by the use of field bags, by squirting kerosine in the infested fields and drawing a rope across the fields so as to get the nymphs as well as adults in contact with kerosine on the water. The cultivators also bagged their fields with *dhoties* turned into temporary bags, previously moistened with a little kerosine.

The appearance of the infested fields.

The infested fields appeared blighted. In the year when the leaf-hoppers appeared early, when the paddy plants were hardly above the

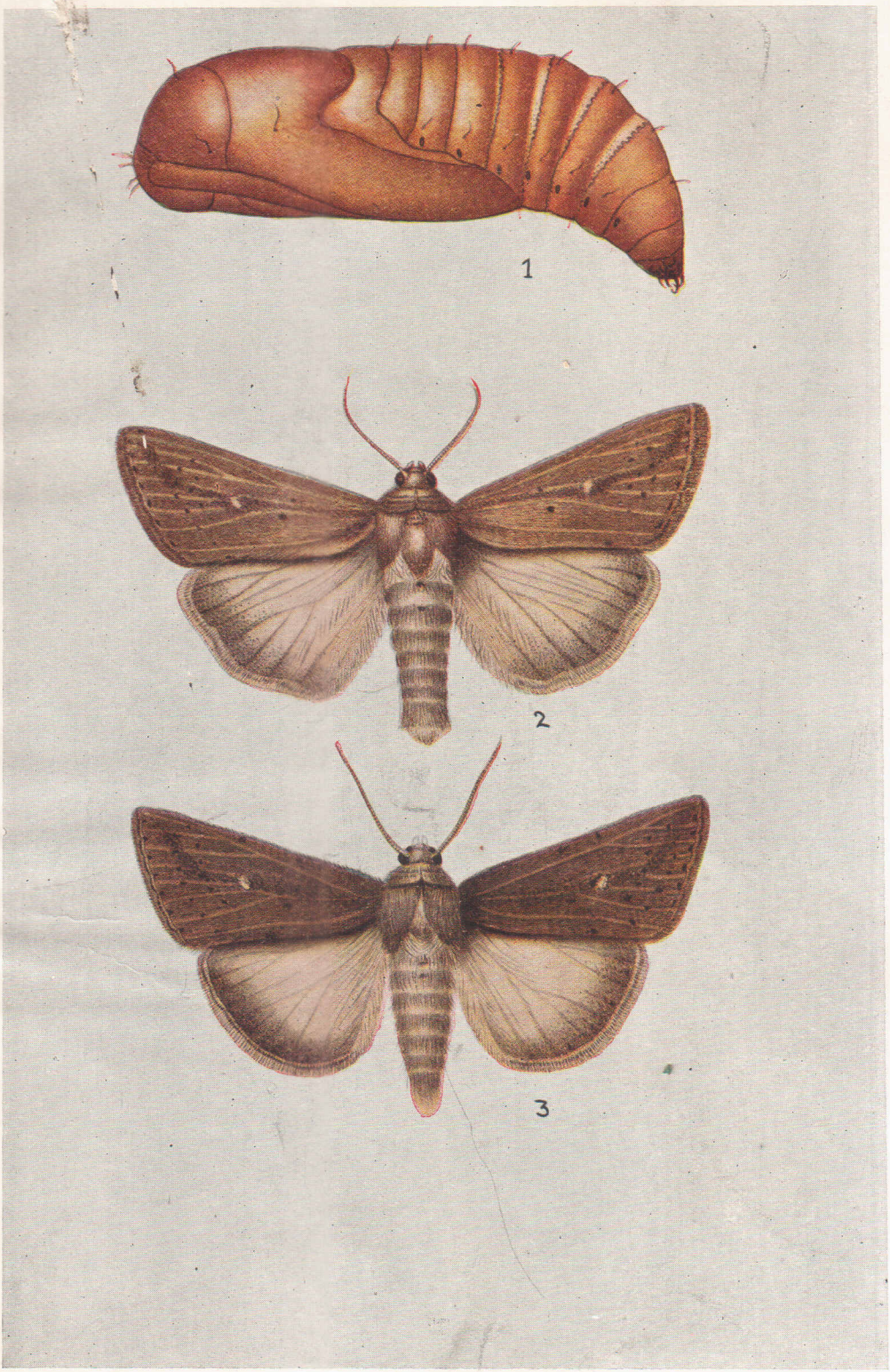
ground, considerable damage was done. The hoppers, both the nymphs and the adult, sucked the juice, in consequence of which the affected plants turned pale brown, then brown and ultimately withered away. If, however, the hoppers appeared at a time when the plants were about to put forth ears, so much sap was drained off that these plants were lowered in vitality and so failed to put forth ears. In places it was also found that if the appearance of the hoppers synchronized with the appearance of the ears on the plants, there was no grain in them and they appeared puckered or prematurely blasted. It was found that in localities where the crop had attained sufficient maturity little or no damage was done. It was also noticed that the early ripening varieties of paddy either entirely escaped damage or were damaged to a very small extent. Late ripening and transplanted varieties as well as those in *Gehunras* lands [lands adjoining villages and enriched from the village washings and the particular habits of the local inhabtants] were the worst sufferers. The reason for this is not far to seek. The varieties of paddy usually grown in *Gehunras* lands are usually late varieties and as such remain green and succulent at the time of the appearance of the hoppers. It was also noticed that the leaf-hoppers preferred to feed on these than the *Harhum* [early ripening] varieties growing on *Bhata* lands [undulating lands with laterite nodules in process of disintegration]. In some places the visitation of the leaf-hoppers on rice plants was associated with the reddening of the water of the infested fields, and it was explained that when the honey-dew exuded by the hoppers—both nymphs and adults —came in contact with the water in the fields, it turned red. I made a search for such fields during September-October 1915, but could in no way associate the discolouration of the infested fields with the honey-dew exuded by the insects. In fact I could then hardly find a field which had turned red markedly. All that I could see, and that too in two or three instances only, was that the water in the infested fields had turned slightly red. This was close to the *Bhata* lands and I could not associate the discolouration with the honey-dew exuded by the hoppers. In fields adjoining fields containing discoloured water the damage was just the same although the water in them had not become discoloured. I did not, in fact, come across a field wherein the damage was more than others containing normal rainwater. No doubt in two or three villages in the Bilaspur District I came across fields where *Sclerotium oryzæ* was bad, especially in *Gurmatia* variety of paddy. If, however, the redness of the infested fields is associated with a fungoid growth, my experience in the worst infested areas deters me from vouchsafing for the correctness or otherwise of the plausible explanation offered for the peculiar phenomenon observed in the hopper infested areas.

Life-history. (Plate 78.)

On the ninth to tenth day after maturity, the female begins to lay eggs in the tissues of the sheathing leaves. At times, when the hoppers are at their worst, eggs may be seen laid in the tissues of midribs of leaves as well as in the edges. But such cases were rather the exception than the rule. In working out the life-history of the pests at Pusa, I found the eggs laid invariably in the edges of the sheathing leaves to stems. There is nothing to show externally the place or places where the eggs have been laid. If, however, a close examination is made of the spots where eggs have been laid with a hand lens, a slight swelling will be apparent. There is no whitish froth or any whitish cretaceous hairs deposited on the eggs to make them conspicuous objects, especially against the greenish background of the leaves. The female when about to lay eggs approaches the edge of a sheathing leaf, makes a longitudinal slit with her strong ovipositor and deposits the eggs in quick succession. The eggs when laid freshly are pale-yellow with two dull red spots. The number of eggs laid varies from 22 to as high as 37. In a specific instance under observation, a female was found to deposit 34 eggs in a slit 9 mm. long.

When the nymph emerges a slit opens at the apex represented by two deep maroon-coloured specks and the head is thrust out. The nymph then squirms from side to side until it is clear out of the egg-shell. It then presents a shiny appearance and is enveloped in a thin membrane which on exposure ruptures allowing the nymph to move about, leaving the amnion attached to the apex of the empty egg-shell as a thin pellicle. The eggs were found parasitized by a small, pale yellow Chalcidid. The parasitized eggs turn black and the adult Chalcidid emerges after making a clean, circular hole in the egg-shell. After the emergence of the parasites, the empty parasitized egg-shells appear deep, fuscous brown with their apices black. The number of parasitized eggs was not large, and the parasite could in no sense be reckoned as an effective check to the development of the hoppers.

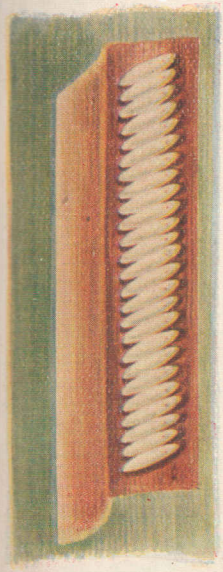
The nymph on coming out of the egg-shell is active and after only a few seconds begins to move about on the leaf. After moving up and down the leaf for a few minutes it soon selects a spot where it fixes itself, and begins to suck the juice. It then exudes the honey-dew which falls on the lower leaves and accumulates there. The nymphs are very active and jump off with the least disturbance. During the hottest part of the day they may be seen clustered together in enormous numbers below leaves. If, therefore, an infested leaf be held up to the light, it will be found to contain a number of punctures representing the spots where the nymphs and the adults had thrust their rostra to suck the sap which



CIRPHIS ALBISTIGMA.

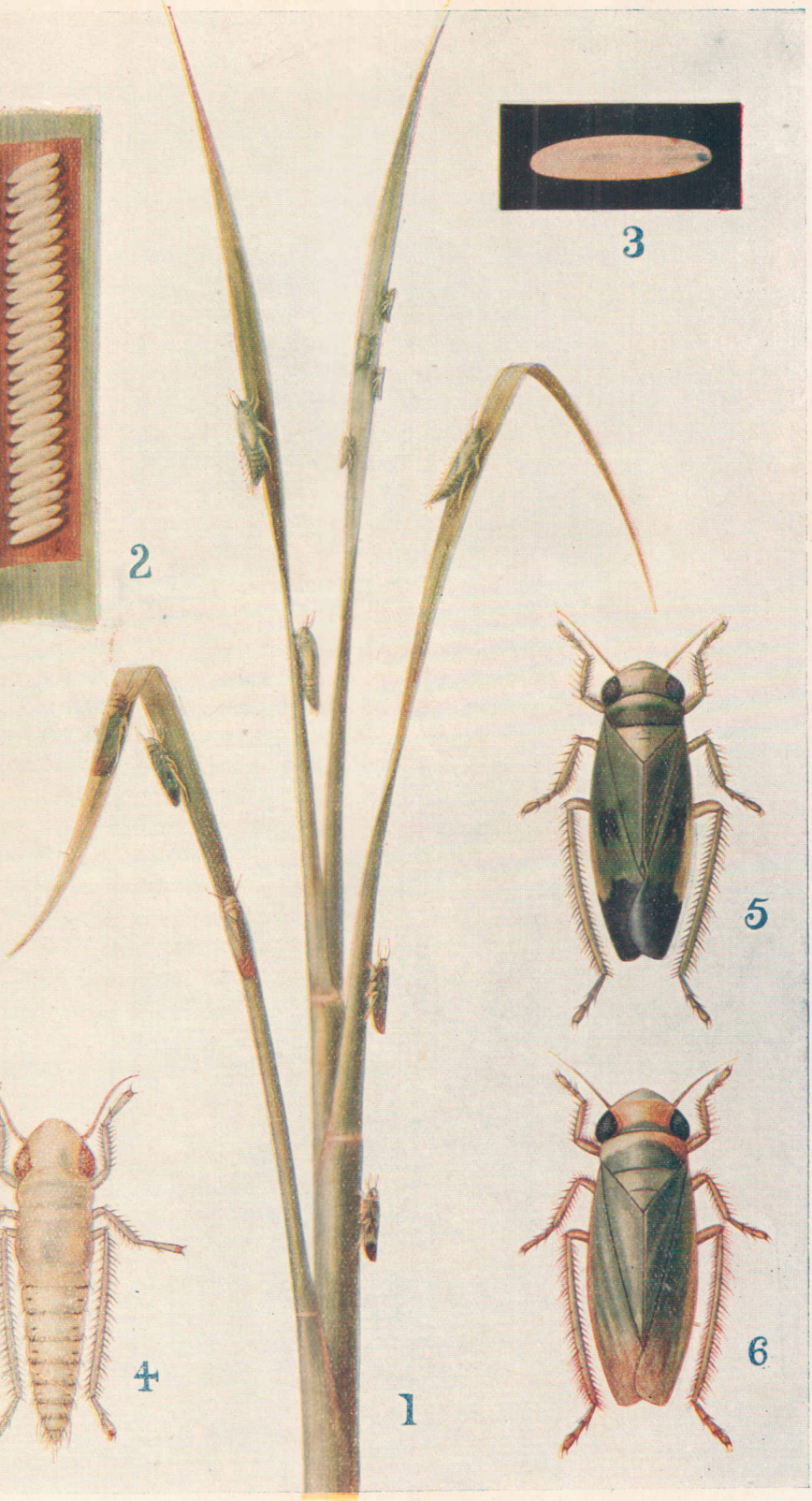
EXPLANATION OF PLATE 78.

Fig. 1. Rice plant with young and adult hoppers on it.
Fig. 2. Eggs in a sheathing-leaf of a plant ×14.
Fig. 3. An egg (much enlarged).
Fig. 4. Nymph, 1st instar ×72
Fig. 5. Male hopper ×15.
Fig. 6. Female hopper ×15.



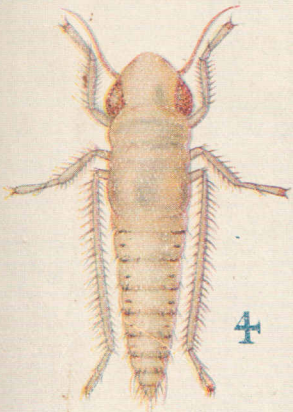
2

3



1

5



4

6

NEPHOTETTIX BIPUNCTATUS.

should have gone ordinarily to the maturing of the plant. In the case of the worst infested fields as many as 167 adults and nymphs were found to feed on a single leaf. Unlike the adults, the nymphs are not attracted to the light.

The nymphs before maturing into adults pass through five moults. At the time of moulting the rostrum is so firmly embedded in the tissues of the leaves or the stems, that if the exuvia are lifted with a teaser, the rostral setæ break off and remain embedded in the tissues. After passing through five moults the adults appear on the leaves and are then represented by two species. The characteristic differences between the two species are :—

Nephotettix bipuncatus, Fabr. (*Fauna of British India Rhynchota*, Vol. IV, p. 359, fig. 228). Yellowish brown, shining, smooth, face (except the lateral margins) and a spot on each side of clypeus black ; tegmina with a spot before the middle and the apical two-fifths black ; lateral spots to sternum and abdomen black. The female is usually without the discal black spot to the tegmina and with the face as described for the varietal male.

Nephotettix apicalis, Motsch.(*Fauna of British India, Rhynchota*, Vol. IV, pp. 360-361, fig. 229). Yellowish virescent, smooth, shining ; face, anterior subimpressed transverse line on vertex between anterior margins of eyes, anterior margin of pronotum, scutellar and commissural margins of clavus, a spot before the middle extending to the claval suture and there acutely produced hindward, apical third of tegmina, sternum, abdomen, greater part of the femora, anterior tibiæ and the tarsi black ; the posterior tibiæ at the bases of the spinules spotted with black ; ventral incisures flavescent.

N. apicalis is closely allied to *N. bipunctatus*, but differs in having the head shorter and more obtuse, anteriorly obtusely rounded and by the marking of same. Head as broad as pronotum, but somewhat shorter, vertex a little longer in the middle than at the eyes, scarcely twice as broad between eyes as long, anteriorly within the margin transversely impressed.

In plain language, the females in both the species are unspotted. They are pale green in colour, with a strong, brownish ovipositor with which they laterate the tissues of the leaves and deposit the eggs. The males in both the species are black, one has two black prominent spots on the wings, in the other there are two oblique black lines. There is very little difference between the females of both the species. The adults, both males and females, remain on the lower surface of leaves mostly near the midribs sucking the juice during the hottest part of the day. At dusk they become active and fly from plant to plant. While feeding

they exude a clear, thin liquid—the honey-dew—which, falling on the leaves below, makes them very sticky. The adults of both the species exhibit a strong predilection for light.

of the two species, *Nephotettix bipunctatus* was the most predominant and the observations regarding life-history, etc., recorded herein relate mostly to *N. bipunctatus*.

Life-cycle.

During September and October 1916, a life-cycle was found to occupy from 17 to 25 days. The egg stage lasts from 4 to 6 days, and the nymphal stages were found to last for 13, 17, 19 and 21 days. In a specific case under observation it was found that a female which matured on the 12th October 1916, began laying eggs on the 21st of the same month.

Hibernation.

From a record extending over sixteen months at Pusa, it was found that the hoppers hibernated during the winter in the adult stage. This was found to be case at Pusa, where the climatic and other conditions are so dissimilar to those prevailing in the rice tract of the Chhattisgarh Division of the Central Provinces, that some time was devoted to finding out the stage in which the adults of the two species hibernated during the winter. The observations made there corroborated the observations made at Pusa and it was found that the adults hibernated in a number of green succulent grasses in dry pond or river beds or in such other places where moisture was available for the grasses to exist. A few adults were also found in long grasses on field embankments and road sides. But the number of adults collected was not very large.

Distribution.

The two species of hoppers have been recorded by Mr. Distant in the *Fauna of British India*, Vol. IV, pp. 359-362 from Calcutta, Pusa, Ranchi, Saraghat, Dacca, Ceylon, Borneo, Sumatra, Philippines, East Africa, Natal and Durban. Dr. Matsumura has recorded *N. apicalis* to occur in China, Japan, Malaya and Europe. In the Pusa collection there are specimens from Balasore, Chapra, Pusa Kankey Farm (Ranchi), Sambhalpur, Raipur, Sakti, Janjgir, Drug, Sindewahi, Coimbatore, and Chanphai in the Lushai Hills.

Though the above record is fairly extensive, the hoppers have been reported as serious pests to rice plants from Chanphai in the Lushai Hills and a tract of country which may be said roughly to extend from Balasore in the East to the borders of the Raipur District in the Central

Provinces in the West. Elsewhere the hoppers are found more or less but not in such large numbers as to be considered as pests. In towns such as Calcutta, the hoppers are known as green-flies which swarm in millions around arc lamps in the streets and in private residences. But they have not been reported as yet as serious pests to rice. The question is well worth studying and I am sure further study of such abstruse and obscure points connected with the life-history, habits and seasonal variations of the pests will afford material which will lead to the adoption of such measures, both preventive and remedial, as would prevent them effectively from laying a heavy toll on the country's produce and thereby denying the patient and sturdy cultivator the fruits of his labour.

Alternative food-plants.

Hitherto the hoppers have been found exclusively on green succulent grasses growing in damp places in pond and river beds as well as on grasses growing on field embankments in suitable localities. They have also been found to some extent on millets, especially Kodon (*Setaria italica*). Besides these, I am unacquainted with any other foodplant on which the hoppers are found to live and to breed.

Local names of the pests.

In the Chhattisgarh Division of the Central Provinces the hoppers are known under the common name of "*Maho*" or "*Mahor*" but preferably the former. The local word conveys an idea of the blight caused by the insects. Some cultivators nicknamed the hoppers as "*Maho*" on account of the honey-dew exuded by them, which made the leaves of the infested plants sticky. In the adjoining Oriya district of Sambhalpur in Bihar and Orissa the pests are known as '*Daoni*,' '*Ghunghutti*' or '*Dhana*.' In the Balasore District they are known as '*Jhatkas*.' The Lushais call them the '*Kumthu*.' Besides these, other minor local names for the hoppers were a legion in the Chhatisgarh Division but that most in common and familiar use was "*Maho*."

Other insects associated with the leaf-hoppers.

During 1915, prior to the appearance of the leaf-hoppers, *Hieroglyphus banian* and *Sogata* spp. appeared in enormous swarms in the Central Provinces and damaged the paddy crop considerably. Later on when the hoppers appeared the following insects were also found in numbers in the infested fields :—

(1) *Athysanus indicus*, Dist.
(2) *Athysanus fusconervosus*, Motsch.

(3) *Thomsoniella albomaculata*, Dist.
(4) *Tettigoniella spectra*, Dist.
(5) *Kolla* sp. near *mimica*.
(6) *Selenocephalus virescens*, Dist.
(7) *Paramesus lineaticollis*, Dist.
(8) *Clovia puncta*, Walk.

In Cuttack and Balasore Districts in Bihar and Orissa, *Pachydiplosis oryzæ* occurred simultaneously with the hoppers and did considerable damage.

Besides these, *Schœnobius bipunctifer*, *Cnaphalocrocis medinalis* and *Chapra mathias* were also found more or less in the fields infested by the hoppers.

Preventive and remedial measures.

A number of measures were tried during 1914 and 1915 and of these the following appear worth adopting in cases of future outbreaks of the pests. It was also found that the measures adopted met with varying success depending very much upon the particular proclivities of the people and the local conditions prevailing in a particular tract in the infested area. In some places, oil for the lamps was available and people were willing to set up lantern traps, in others people readily took to bagging the hoppers. In some places the local cultivators, profiting by their previous experience, had put down a greater portion of the area cultivated by them under early maturing varieties, thereby getting a crop whereby to maintain themselves as well as their cattle. In fact, some such innovation in local methods of cultivation was seriously mooted by us in case the pests ran their course for a series of years. But fortunately for the *raiyats* the pests appeared for two years only and have not been reported as yet from any rice-growing tract in the Central Provinces since 1916.

1. As far as possible the cultivators should be impressed with the necessity of ploughing up their fields after the crop has been harvested and thereafter to allow the cattle to graze freely in the cultivated areas.

2. If there have been good rains during March-April, and the rainfall is not heavy during July-August, with a considerable break in the rains in the latter part of August and early September with a spell of hot sunny days, the nurseries as well as places containing green grasses should be bagged either with hand-nets or *dhoties* turned into bags and lightly sprinkled with kerosine oil.

3. Considerable pioneer work remains yet to be done, but if from data collected in the areas affected last it is found that the number of hoppers is larger than in normal years, systematic bagging is to be

started. No doubt, the measure is not much appreciated by the local people who are either loath to buy the cloth required for the bags or are unable to contribute labour necessary to work the bags. But in the long run, if the unexpected happens, it is possible that they will take to the measure to escape the loss caused by the hoppers.

4. To set up light-traps during July-August when there are only a few hoppers and again at the end of September when they reach their maximum developments. The local people do not like the idea of going to their fields at night and putting up the lanterns. They are mortally afraid of vermin which in some parts are very common. But the appointment of a few specially trained men to take charge of two or three villages at a time was found to work well, and the local cultivators were willing to pay for the extra cost of maintaining a *Kamdar*.

Publications of the Imperial Department of Agriculture in India.

To be had from :—

The Office of the Agricultural Adviser to the Government of India, Pusa, Bihar, and from the following Agents :—

1. Thacker, Spink & Co., Calcutta.
2. W. Newman & Co., Calcutta.
3. Rai M. C. Sarkar Bahadur & Sons, Calcutta.
4. Higginbothams, Ltd., Madras.
5. Thompson & Co., Madras.
6. D. B. Taraporevala, Sons & Co., Bombay.
7. Thacker & Co., Ltd., Bombay.
8. Sunder Pandurang, Bombay.
9. Rai Sahib M. Gulab Singh & Sons, Lahore.
10. Manager, Educational Book Depôt, Nagpur.

A complete list of the publications of the Imperial Department of Agriculture in India can be obtained on application from the Agricultural Adviser to the Government of India, Pusa, Bihar, or from any of the above mentioned agents.

These publications are :—

1. The *Agricultural Journal of India.* A Journal dealing with subjects connected with agricultural economics, field and garden crops, economic plants and fruits, soils, manures, methods of cultivation, irrigation, climatic conditions, insect pests, fungus diseases, co-operative credit, agricultural cattle, farm implements, and other agricultural matters in India. Illustrations, including coloured plates, form a prominent feature of the Journal. It is edited by the Agricultural Adviser to the Government of India, and is issued once every two months or six times a year. *Annual Subscription*, Rs. 6 or 9*s.* 6*d.*, including postage. Single copy, R. 1-8 or 2*s.*
2. Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Imperial Cotton Specialist).
3. Annual Report on the Progress of Agriculture in India.
4. Proceedings of the Board of Agriculture in India.
5. Proceedings of Sectional Meetings of the Board of Agriculture.
6. Memoirs of the Imperial Department of Agriculture in India :
   - (*a*) Botanical Series.
   - (*b*) Chemical Series.
   - (*c*) Entomological Series.
   - (*d*) Bacteriological Series.
   - (*e*) Veterinary Series.
7. Bulletins issued by the Agricultural Research Institute, Pusa.
8. Books.

The following are the publications of the last two years :—

Scientific Reports of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist), for the year 1918-19. Price, R. 1-4 or 2*s.*

Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Secretary, Sugar Bureau), for the year 1919-20. Price, R. 1.

Report on the Progress of Agriculture in India for the year 1917-18. Price, R. 1-8 or 2*s.* 3*d.*

Report on the Progress of Agriculture in India for the year 1918-19. Price, R. 1-8 or 2*s.* 3*d.*

Proceedings of the Board of Agriculture in India, held at Pusa on the 1st December, 1919, and following days (with Appendices). Price, As. 12 or 1*s.* 3*d.*

Proceedings of the Second Meeting of Mycological Workers in India, held at Pusa on the 20th February, 1919, and following days. Price, As. 11 or 1*s.*

Proceedings of the First Meeting of Agricultural Chemists and Bacteriologists, held at Pusa on 24th February, 1919, and the following days. Price, R. 1 or 1*s.* 6*d.*

Proceedings of the First Meeting of Veterinary Officers in India, held at Lahore on the 24th March, 1919, and following days (with Appendices). Price, As. 8 or 9*d.*

Proceedings of the Third Entomological Meeting, held at Pusa in February, 1919. Price, Rs. 17-8.

MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA.

Botanical Series.

Vol. X, No. I. The Rice Worm (*Tylenchus angustus*) and its Control, by E. J. BUTLER, M.B., F.L.S. Price, R. 1-4 or 2*s*.

Vol. X, No. II. Studies in Indian Sugarcanes, No. 4. Tillering or Underground Branching, by C. A. BARBER, C. I. E., SC.D., F.L.S. Price, R. 4-4 or 7*s*.

Vol. X, No. III. Studies in Indian Sugarcanes, No. 5. On testing the suitability of sugarcane varieties for different localities, by a system of measurements. Periodicity in the growth of the sugarcane, by C. A. BARBER, C.I.E., SC.D., F.L.S. Price, R. 1-12 or 3*s*.

Vol. X, No. IV. A *Pythium* Disease of Ginger, Tobacco and Papaya, by L. S. SUBRAMANIAM. Price R. 1-8 or 2*s*. 6*d*.

Vol. X, No. V. Studies in the Pollination of Indian Crops, 1, by A. HOWARD, C.I.E., M.A.; GABRIELLE L. C. HOWARD, M.A.; and ABDUR RAHMAN KHAN. Price R. 1-4 or 2*s*. 6*d*.

Vol X, No. VI. "Kumpta" Cotton and its Improvement, by G. L. KOTTUR, B. Ag. Price, R. 1-12 or 3*s*.

Vol. XI, No. I. Some Aspects of the Indigo Industry in Bihar. Part I. The Wilt Disease of Indigo. Part II. The factors underlying the seed production and growth of Java Indigo, by ALBERT HOWARD, C.I.E., M.A., and GABRIELLE L. C. HOWARD, M.A., with the assistance of CHOWDHARY RAMDHAN SINGH and MAULVI ABDUR RAHMAN KHAN. Price, R. 1-2 or 2*s*.

Vol. XI, No. II. Studies in Diseases of the Jute Plant. (1) *Diplodia Corchori*, Syd., by F. J. F. SHAW, D.SC., A.R.C.S., F.L.S. (*In the press.*)

Vol. XI, No. III. Morphology and Parasitism of *Acrothecium Penniseti* n. sp. (A new Disease of *Pennisetum typhoideum*), by MANORANJAN MITRA, M.SC. (*In the press.*)

Chemical Series.

Vol. V, No. IV. Cholam (*A. Sorghum*) as a Substitute for Barley in Malting Operations, by B. VISWANATH, T. LAKHSHMANA ROW, B.A., and P. A. RAGHUNATHASWAMI AYYANGAR, D.P. AG. Price, As. 12 or 1*s*.

Vol. V, No. V. The Phosphate Requirements of some Lower Burma Paddy Soils, by F. J. WARTH, M.SC., B.SC., and MAUNG PO SHIN. Price, R. 1-12 or 3*s*. 3*d*.

Vol. V, No. VI. Absorption of Lime by Soils, by F. J. WARTH, M.SC., B.SC., and MAUNG PO SAW. Price, R. 1-2 or 2*s*.

Vol. V, Nos. VII & VIII. The Gases of Swamp Rice Soils, V—A. Methane-oxidizing Bacterium from Rice Soils, by P. A. SUBRAHMANYA AYYAR, B.A.; and The Gases of Swamp Rice Soils, VI—Carbon Dioxide and Hydrogen in relation to Rice Soils, by W. H. HARRISON, D.SC. Price, As. 12 or 1*s*. 3*d*.

Vol. V, No. IX. The Retention of Soluble Phosphates in Calcareous and Non-calcareous Soils, by W. H. HARRISON, D.SC., and SURENDRA LAL DAS, M.SC. (*In the press.*)

Vol. V, No. X. Windrowing Sugarcane in the North-West Frontier Province. Part I.—The Effect on the Economical and Agricultural situation, by W. ROBERTSON BROWN. Part II.—The Effect on the Composition of Sugarcane, by W. H. HARRISON, D.SC., and P. B. SANYAL, M.SC. Price, As. 12 or 1*s*.

Entomological Series.

Vol. V, No. V. The Rice Leaf-hoppers (*Nephotettix bipunctatus*, Fabr. and *Nephotettix apicalis*, Motsch.), by C. S. MISRA, B.A. Price, R. 1-8 or 3*s*.

Vol. V, No. VI. *Lantana* Insects in India. Being the Report of an Inquiry into the Efficiency of Indigenous Insect Pests as a Check on the Spread of *Lantana* in India, by RAO SAHIB Y. RAMACHANDRA RAO, M.A., F.E.S. Price, R. 2-4 or 4*s*. 6*d*.

Vol. VI, Nos. I—IX. Life-histories of Indian Insects: Microlepidoptera, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S. Price, Rs. 7-8 or 11*s*. 3*d*.

Vol. VII, Nos. I & II. New Indian Gall Midges (Diptera), by E. P. FELT, and Description of a Rhinocyphine larva from Shillong, by MAJOR F. C. FRASER, I.M.S. Price, As. 12 or 1*s*. 6*d*.

PLATE 18.

Bitter-gourd-vine Gall-fly.
a, stem of bitter-gourd-vine with two galls ; *b*, gall cut open, showing maggots ; *c*, fly, magnified (×13).

MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA—*contd.*

Bacteriological Series.

Vol. I, No. VIII. Pebrine in India, by C. M. HUTCHINSON, C.I.E., B.A. Price, Rs. 3-8 or 5*s.* 6*d.*
Vol. I, No. IX. Studies on the Root Nodule Organism of the Leguminous Plants, by N. V. JOSHI, M.SC., B.A., L.AG. Price, R. 1-4 or 2*s.* 6*d.*

Veterinary Series.

Vol. III, No. II. The Virulence of Tubercle Bacilli isolated from Bovine Lesions in India, by A. L. SHEATHER, B.SC., M.R.C.V.S. (*In the press.*)
Vol. III, No. III. Bovine Lymphangitis, by A. L. SHEATHER, B.SC., M.R.C.V.S. (*In the press.*)

BULLETINS ISSUED BY THE AGRICULTURAL RESEARCH INSTITUTE, PUSA.

No. 85. Soil Drainage, by R. G. ALLAN, M. A. Price, As. 4 or 5*d.*
No. 86. A. New Nematode causing Parasitic Gastritis in Calves, by A. L. SHEATHER, B.SC., M.R.C.V.S. Price, As. 4 or 5*d.*
No. 87. A Contribution to our Knowledge of South Indian Coccidæ, by T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S. Price, As. 14 or 1*s.* 6*d.*
No. 88. Cawnpore-American Cotton : An Account of Experiments in its Improvement by Pure Line Selection and of Field Trials, 1913-1917, by B. C. BURT, B.SC., and NIZAMUDDIN HAIDER. Price, As. 10 or 1*s.*
No. 89. Second Hundred Notes on Indian Insects. Price, R. 1-4 or 2*s.*
No. 90. A Malarial Parasite in the Blood of a Buffalo, by A. L. SHEATHER, B.SC., M.R.C.V.S. Price, As. 6 or 7*d.*
No. 91. Notes on Practical Salt Land Reclamation, by G. S. HENDERSON, N.D.A., N.D.D. Price, As. 6.
No. 92. Syngamus laryngeus in Cattle and Buffaloes in India, by A. LESLIE SHEATHER, B.SC., M.R.C.V.S., and A. W. SHILSTON, M.R.C.V.S. Price As. 6.
No. 93. The Orange : A Trial of Stocks at Peshawar, by W. ROBERTSON BROWN. Price As. 6.
No. 94. A Preliminary Note on the Behaviour in North India of the first batch of Sugarcane Seedlings distributed from the Sugarcane-breeding Station, Coimbatore, by T. S. VENKATRAMAN, B.A. Price, As. 8.
No. 95. A Note on the Treatment of Surra in Camels by Intravenous Injections of Tartar Emetic, by H. E. CROSS, M.R.C.V.S., D.V.H., A.SC. Price, As. 2.
No. 96. A Summary of Experiments on Rice in Bihar and Orissa from 1912 to 1919, by G. C. SHERRARD, B.A. (*In the press.*)
No. 97. *Ustilago Crameri*, Koern. on *Setaria italica*, by S. SUNDERARAMAN, M.A. Price,
No. 98. The Course that Surra runs in Camels when Naturally Contracted and when Artificially Inoculated, by H. E. CROSS, M.R.C.V.S., D.V.H., A.SC. (*In the press.*)
No. 99. The Course that Camel Surra runs in Ponies, Buffaloes and other Animals, by H. E. CROSS, M.R.C.V.S., D.V.H., A.SC. (*In the press.*)
No. 100. Annotated List of Indian Crop-Pests, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S. Price, R. 1-8.
No. 101. Some Insects recently noted as injurious in South India, by T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S. Price, As. 8.
No. 102. Borers in Sugarcane, Rice, etc., by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. GHOSH, B.A. Price, R. 1.
No. 103. Some Indian Economic Aleyrodidæ, by C. S. MISRA, B.A. Price, As. 8.
No. 104. The Rice Leaf-hoppers, by C. S. MISRA, B.A. Price, As. 6.
No. 105. Cotton Bollworms in India, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. S. MISRA, B.A. Price, As. 8.
No. 106. The Pink Bollworm in Egypt, by LEWIS H. GOUGH, PH.D., F.E.S. Price, R. 1.
No. 107. Experiments in Egypt on the Survival of the Pink Bollworms (resting stage larvæ) in ripe damaged Cotton Bolls buried at different depths, by F. C. WILLCOCKS. Price, As. 5.
No. 108. Some Pests of Cotton in North Bihar, by C. S. MISRA, B.A. Price, As. 6.
No. 109. *Tukro* Disease of Mulberry, by C. S. MISRA, B.A. Price, As. 4.
No. 110. The Preservation of Wood against Termites, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. GHOSH, B.A. Price, As. 3.

BULLETINS ISSUED BY THE AGRICULTURAL RESEARCH INSTITUTE, PUSA—*contd.*

No. 111. Stored Grain Pests, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., and C. C. Ghosh, B.A. Price, As. 14.

No. 112. Notes on Rearing insects in hot Climates, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., and C. C. Ghosh, B.A. Price, As. 7.

No. 113. Hints on Collecting and Preserving Insects, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S. Price, As. 10.

No. 114. The Preparation and Reproduction of Scientific Illustrations, by A. W. Slater. Price, As. 4.

No. 115. Note on Plant Imports into India, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S. Price, As. 7.

INDIGO PUBLICATIONS.

No. 6. The Effect of Manuring with Superphosphate and Sannai on the Yield of Crops on Indigo Planters' Estates in Bihar—especially of Rabi Crops in the Season 1918, 1919, by W. A. Davis, B.Sc., A.C.G.I. Price, As. 6.

No. 7. The Conditions affecting the Quality of the Java Indigo Plant (Leaf yield and richness of the leaf in indigotin), by W. A. Davis, B.Sc., A.C.G.I. Price, As 9.

No. 8. Note on the Development of the Indigo Industry in Assam in conjunction with Tea and other Crops, by W. A. Davis, B.Sc., A.C.G.I. (*In the press.*)

BOOKS.

"Indian Insect Pests," by H. Maxwell Lefroy, M.A., F.E.S., F.Z.S. Price, R. 1-8 or 2*s.* (*Out of print.*)

"Indian Insect Life," by H. Maxwell Lefroy, M.A., F.E.S., F.Z.S.; and F. M. Howlett, B.A. 786 pp. Price, R. 20 or 30*s.* (*Out of print.*)

"Wheat in India," by Albert Howard, M.A., A.R.C.S., F.L.S.; and Gabrielle L. C. Howard, M.A. 288 pp. Price, R. 5 or 7*s.* 6*d.*

"A Description of the Imperial Bacteriological Laboratory, Muktesar: Its Work and Products," by Major J. D. E. Holmes, M.A., D.Sc., M.R.C.V.S. Price, As. 8 or 9*d.*

"Agriculture in India," by James Mackenna, M.A., I.C.S. Price, As. 4 or 5*d.*

"Some Diseases of Cattle in India. A Handbook for Stock: owners." Price, As. 8 or 9*d.*

"The Importance of Bacterial Action in Indigo Manufacture," by C. M. Hutchinson, B.A. Price, As. 2 or 3*d.*

Report of the Indian Cotton Committee. Vol. I, Report; Vol II, Maps and Plans. Price, R. 1 per volume. (Superintendent, Government Printing, India, Calcutta.)

Minutes and evidence taken before the Indian Cotton Committee:—

Vol. I. Agriculture, Part I (United Provinces, Central Provinces, Burma, North-West Frontier Province, Punjab and Sind). Price, Rs. 2-6.

Vol. II. Agriculture, Part II (Bombay, Madras, Bengal, Bihar and Orissa, Imperial Officers, Central India, Baroda, Hyderabad and Mysore). Price, Rs. 2-13.

Vol. III. Irrigation (United Provinces, Central Provinces, North-West Frontier Province, Bengal and Sind). Price, R. 1-12.

Vol. IV. Commercial, Part I (United Provinces, Central Provinces, Burma, Punjab, Sind and Bombay). Price, Rs. 2-2.

Vol. V. Commercial, Part II (Madras, Bengal, Imperial Officers, Central India, Baroda and Hyderabad). Price, R. 1-12.

SGPI—M—98 AA to G of I—21-5-21—1,000

THE IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH

A New Pest (*Acanthiophilus helianthi* Rossi, Trypetidae) of Safflower in India

BY

HEM SINGH PRUTHI

AND

H. L. BHATIA

Reprinted from

The Indian Journal of Agricultural Science

Vol. X, Part II, April, 1940

PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI
PRINTED BY THE MANAGER, GOVERNMENT OF INDIA PRESS, NEW DELHI
1940

A NEW PEST (*ACANTHIOPHILUS HELIANTHI* ROSSI, TRYPETIDAE) OF SAFFLOWER IN INDIA

A NEW PEST (*ACANTHIOPHILUS HELIANTHI* ROSSI, TRYPETIDAE) OF SAFFLOWER IN INDIA

BY

HEM SINGH PRUTHI, M.Sc., Ph.D. (CANTAB), F. N. I.

Imperial Entomologist

AND

H. L. BHATIA, M.Sc.

Imperial Agricultural Research Institute, New Delhi

(Received for publication on 24 August 1939)

(With Plate III)

INTRODUCTORY

ABOUT the middle of March, 1939, in the experimental plots of safflower (*Carthamus tinctorius*) of the Imperial Economic Botanist at New Delhi, some of the flower buds presented a diseased appearance, the chief symptom of which was an odorous juice oozing out from the apical region of the buds. Such buds were found to contain dirty-white maggots of a fruit fly which has been identified as *Acanthiophilus helianthi* Rossi. This is the first record of this genus and species from India.

The pest was very active during March, April and May and caused serious damage in both early and late sown varieties of safflower, the infestation being as high as 90 per cent. The young florets were damaged by the maggots with the result that the buds opened partially or did not open at all.

As the cultivation of safflower is being considerably extended in India for the dye obtained from its flowers and for the oil obtained from its seeds, there is danger of the spread of the pest which can be carried in the pupal stage mixed amongst the seeds from one place to another.

Detailed observations on the biology of the pest have been taken during the last spring and summer. As the pest is new and is of considerable potential importance, the results of investigation so far obtained are being published, so that workers in other regions of India may be able to recognize the pest if it occurs there.

DISTRIBUTION AND HOST PLANTS

Chiefly through the courtesy of Mr. Munro, Entomologist, Department of Agriculture, South Africa, we have been able to obtain the following information about the distribution of *Acanthiophilus helianthi* Rossi in other countries :—

The species was originally described by Rossi in 1790 and has been referred to in literature as *Trypeta eluta* by several workers [Meigen, 1826 ; Efflatoun

1924, etc.]. The species is recorded from the Canary Islands, the Mediterranean region, Central Europe, North Africa, Egypt, the Sudan, Erytrea, Asia Minor, Persia and Central Asia. The recorded host plants are : *Centaurea* spp., *Cnicus lanceolatus*, *Silybum marianum*, *Onopordon illyricum*, *Amherboa lippi*, *Leuzea conifera* and *Carthamus tinctorius*. According to Hendel [1927], the maggots as a rule live in the flower heads, producing galls. but they are also found at times in the stems, as in the case of *Cnicus lanceolatus*. Most of the host plants listed above seem to be more or less weeds, with the exception of *Carthamus tinctorius* (safflower), with regard to which Hendel [1927], reports a record by Handlirsch of rearing the maggots from the flower head but does not state the locality.

As stated already, there is no previous record of the occurrence of *A. helianthi* from India, but probably the fly recorded attacking seeds in plants of safflower [Rati Ram, 1927] in the Central Provinces was this species.

Nature of damage

The flies were observed on wing in the field for the first time about the middle of March and infestation of the safflower buds by the maggots was evident a week afterwards. The maggots feed upon the essential organs of the florets and even bore into the thalamus. The infested bud begins to rot and the fluid thus produced oozes out from its apical portion and gives it a damp appearnace (Plate III, fig. 2). If such a bud is squeezed between the fingers, the fermented liquid along with one or two maggots come out of the tip of the bud. Furthermore, in advanced stage of attack, the florets become black, presenting an emaciated and withered appearance (Plate III, fig. 3.)

Incidence of the pest in various varieties

Out of the 34, varieties grown for experimental purposes by the Imperial Economic Botanist, the felted varieties (No. 11—15) and the varieties No. 20-22, 30 and 34 were attacked more than the rest, early in the season, viz., from the third week of March up to the end of the first week of April. All the varieties named above are much less spiny and are late in flowering. The second generation of the pest which lasted during the second and third weeks of April was rather small in numbers, probably on account of the activity of the parasites and the predator described hereafter. In the fourth week of April the third generation of the fly was in evidence and the incidence increased rapidly in all the varieties, the degree of infestation being again higher in the felted and the less spiny varieties as compared to the spiny ones. A statement of the attack of the pest in different varieties during the season would be found in the appendix.

It may be added that incidence in the wild safflower which is very spiny was lower than in any of the spiny cultivated varieties. However, after the first week of May when all the cultivated varieties had been harvested, the pest was found in abundance in the wild safflower, which was in flower and was found growing along the field drains and elsewhere in uncultivated areas.

LIFE-HISTORY AND DESCRIPTION OF VARIOUS STAGES

The flies were observed laying eggs in the field from sunrise till about noon. For oviposition the fly prefers a young bud, walks over its surface several times, pricks it at a number of places with its black and rather shiny ovipositor, the duration of each pricking being about 5 seconds, and finally selects a place where it lays the eggs. The behaviour of the female in the actual process of oviposition was observed to be different in several respects from other common fruit flies, viz., *Dacus* spp. During this process which lasts about two minutes, the female slightly bends the abdomen, its ovipositor in action making an obtuse angle with the surface of the bud. It is entirely motionless during egg-laying, appearing as if it is dead. After laying eggs, which may vary in number from 6 to 24 in a cluster, the female lashes its ovipositor up and down in the air, cleans it with its hind pair of legs before retracting its extended parts into its basal portion.

The eggs are laid in punctures either on the innerside of a bract belonging to the innermost row of bracts of the involucre (Plate III, fig. 4), or on a membraneous calyx leaf of one of the peripheral ray florets or on the corolla of a ray floret. Usually one and in some cases two egg-punctures are observed on one bud (Plate III, fig. 2). The egg (Plate III, fig. 5) is white when freshly laid. It is cylindrical, elongated (1·12 mm.×0·2 mm.), truncated and drawn out at one pole and narrowed at the other pole which has a minute knob. The drawn-out region of the egg is hyaline. The chorion is marked all over, except at the truncated pole, with elongated, hexagonal areas converging towards the opaque knobbed end. During hatching, which takes place usually in the morning hours in the laboratory, a slit appears at the hyaline pole and the young maggot wriggles out (Plate III, fig. 6). The young maggot begins to feed on the florets at once. It is 0·75 mm. × 0·2 mm., creamy-white, cylindrical and narrow in the head region (Plate III, fig. 7). The segments are clearly marked. The cephalo-pharyngeal skeleton is slightly chitinized. The maggot at this stage is metapneustic, only the posterior pair of spiracles being present. Each spiracle has two slits.

The full-grown maggot (Plate III, fig. 8) measures 5·0 mm. × 1·5 mm. It is light ochraceous, cylindrical, broad in posterior region and gradually tapering in the anterior and pointed at the head. The posterior end of the maggot is almost truncated. The head is pear-shaped, with the oral opening situated on the ventral side and bears :— (*i*) a pair of antennae ; each antenna being composed of apparently one joint which is minute, cylindrical and has a knob-like apex (Plate III, fig. 10, *an.*) ; (*ii*) maxillary palps : each palp is situated just below the corresponding antenna and has three to four papilli-form sensoria (Plate III, fig. 10, *m. p.*) ; (*iii*) the cephalo-pharyngeal skeleton, which is a highly chitinous structure and extends up to the first thoracic segment (Plate III, fig. 11). It is composed of the following :—

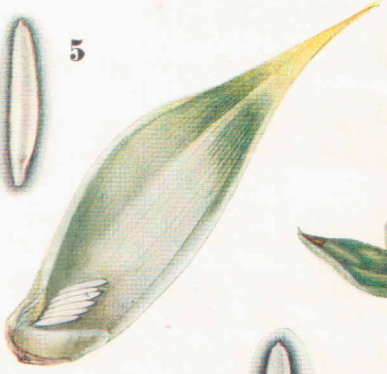
(1) A pair of oral hooks or mandibular sclerites or mandibular hooks, which are furnished each with two strong teeth ; the apical tooth is curved and the pre-apical tooth, which is smaller and less curved, is directed downwards and somewhat backwards.

LIFE-HISTORY AND DESCRIPTION OF VARIOUS STAGES

PLATE III

FIG. 1. Healthy bud (Natural size)
FIG. 2. Damaged bud (Natural size)
FIG. 3. Vertical section of damaged bud (Natural size)
FIG. 4. An egg mass (×4)
FIG. 5. The egg (×16)
FIG. 6. The hatching out maggot (×16)
FIG. 7. The newly hatched maggot (×16)
FIG. 8. The Full-grown maggot (×10)
FIG. 9. The anterior spiracle of one side (×192)
FIG. 10. The antenna and maxillary palp of one side (highly magnified)
FIG. 11. The cephalo-pharyngeal skeleton (×80)
FIG. 12. The posterior spiracles (×100)
FIG. 13. The pupa (×10)
FIG. 14. The female fly (×10)
FIG. 15. The head of the imago (×10)

1

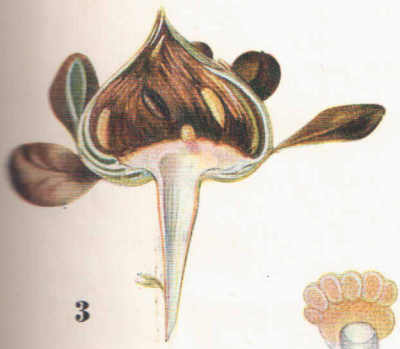


4

5

2

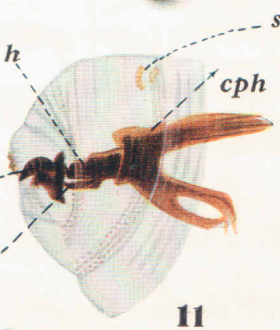
6



3

7

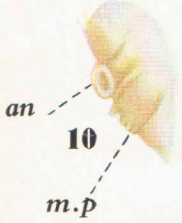
9



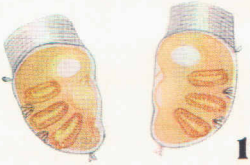
11

13

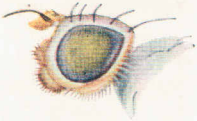
8



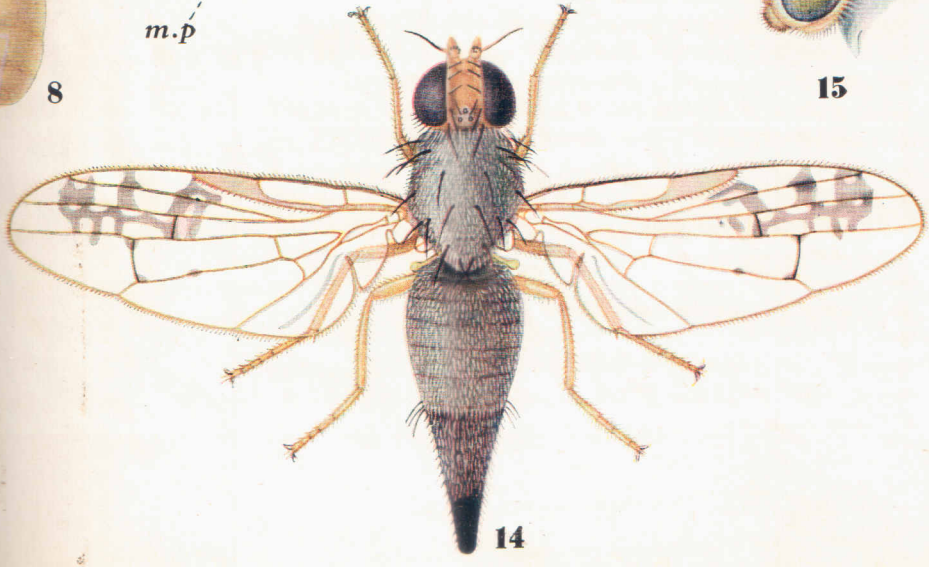
10



12



15



14

(2) A pair of hypostomal or intermediate sclerites (*h*). They are elongated, the broad posterior margin being one and a half times or twice the narrow anterior margin. A pair of rod-shaped sub-hypostomal sclerites (*s. h.*) connects these sclerites with the oral hooks.

(3) Cephalo-pharyngeal sclerite (*Cph.*) which is made up of two shafts united anteriorly, the free portions being forked. Posteriorly, each branch of the fork is further divided into two appendages.

The body of the full-grown maggot has besides the head, 11 visible segments, three thoracic and eight abdominal. At this stage the maggot is amphipneustic, the anterior and posterior spiracles being borne by the first thoracic and the last body segment respectively (Plate III, figs. 8, 9, 12). The long tracheal tubes are visible within the integument. The anterior spiracles are cup-shaped, the margin of each spiracle being fringed with six oval lobes. The posterior spiracles are almost reniform, each possessing three elongated oval slits which are notched at the peripheral end. The inner walls of the slits are chitinized and fimbriated. In each of the inter-spiracular areas there are one to four very minute hyaline lanceolate processes. The pseudopods, which are clearly seen in the abdominal region of the maggots of several species of fruit flies especially of the subfamily Dacinæ, are not distinct in this species. Girdles of four to eight rows of minute conical spines with their apices directed backwards are found in the inter-segmental region of the body. There are fewer rows of spines in the thoracic than in the abdominal segments. The maggot is not capable of jumping, a habit which is so characteristic of the maggots of other Trypetid flies, particularly those infesting fruits.

Pupation generally takes place in the flower bud, the puparia being rarely met with in the soil. The puparium (Plate III, fig. 13) measures 4·25 mm. × 1·75 mm. It is barrel-shaped, black with a metallic tinge. There is a small depression in the thoracic region. The larval girdles of spines and the spiracles are retained and occupy the same positions as in the maggot.

The flies emerge and leave the infested flower bud through small holes on its surface, previously made by the full-grown maggot, each exit hole being about 2 mm. in diameter. The newly emerged flies are rather sluggish, their eyes emerald-green (Plate III, fig. 15) and the body ash-grey. The greyish markings on the apices of wings are not well developed. The flies soon become active and resume their normal appearance within a few hours in the field. They are ash-coloured, bristly, with reddish-brown frons and light brown legs. The male is smaller in size than the female (Plate III, fig. 14) which is about 6·5 mm. in length. The flies are lovers of sunshine flying about flower heads of safflower from sunrise to sunset.

The duration of various stages (average of five readings) in April in the laboratory having average maximum and minimum temperatures of 85·2°F. and 78·5°F, respectively, was as follows : egg, 25 hours ; maggot and pupa, each seven days. The adults could be kept alive when fed on peptone, yeast and sugar under laboratory conditions for about ten days but one male specimen lived as long as five weeks. During the period of six weeks from about the middle of March up to the first week of May in the safflower season the fly completes three generations.

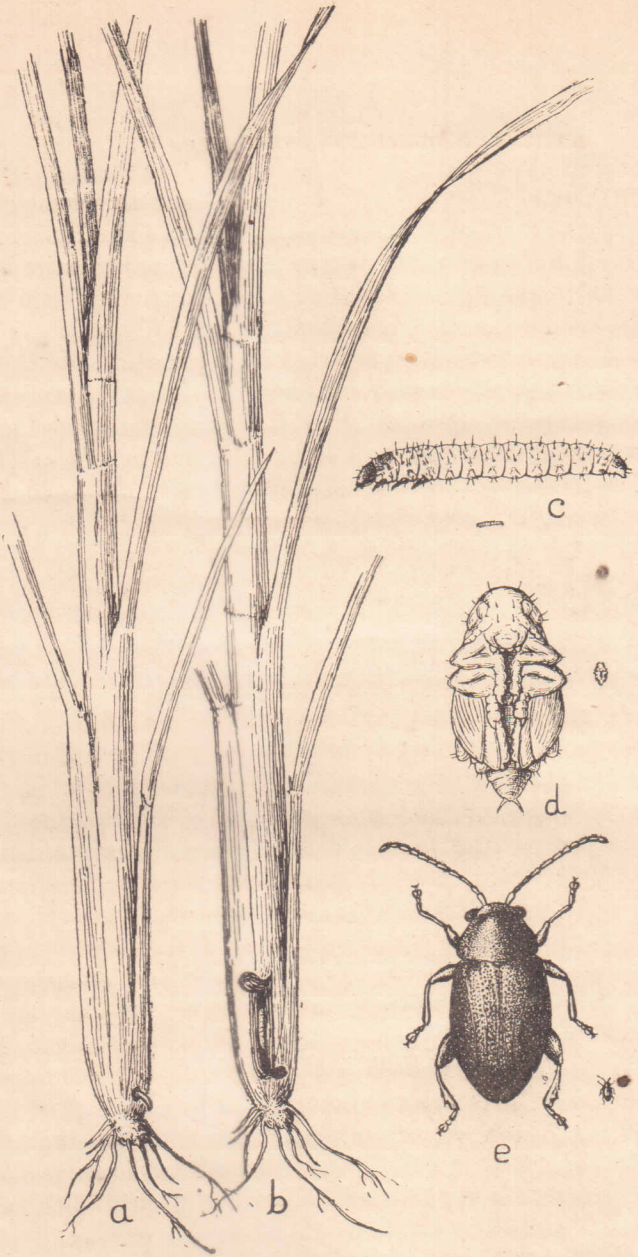


Fig. 1.—*Chætocnema* sp. (C. S. 1923) ; *a*, larva eating into the stem *b*, stem cut open to show the larva inside it ; *c*, larva ; *d*, pupa ; *e*, beetle ; *c*, *d*, *e* are shown of natural sizes and magnified (×11).

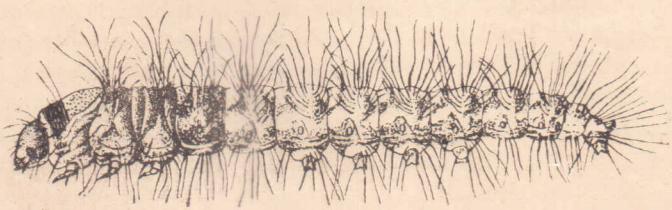


Fig. 2.—C. S. 1696 ; larva, about half grown, natural size and magnified.

INDIGO PUBLICATIONS

No. 7. The Conditions affecting the Quality of the Java Indigo Plant (Leaf yield and richness of the leaf in indigotin), by W. A. DAVIS, B.SC., A.C.G.I. Price, As. 9.

No. 8. Note on the Development of the Indigo Industry in Assam in Conjunction with Tea and other Crops, by W. A. DAVIS, B.SC., A.C.G.I. Price, As. 3.

No. 9. The Nature of the Changes Occurring during the Extraction of Indigo from the Java Plant (*Indigofera arrecta*), by W. A. DAVIS, B.SC., A.C.G.I. Price, R. 1.

No. 10. Note on the Deterioration of Indigo Seed during Storing, by Major W. R. G. ATKINS, SC.D., F.I.C. Price, As. 3.

BOOKS

"Wheat in India," by ALBERT HOWARD, M.A., A.R.C.S., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. 288 pp. Price, Rs. 5 or 7*s.* 6*d.*

"A Description of the Imperial Bacteriological Laboratory, Muktesar: Its Work and Product," by MAJOR J. D. E. HOLMES, M.A., D.SC., M.R.C.V.S. Price, As. 8 or 9*d.*

"Agriculture in India," by JAMES MACKENNA, M.A., I.C.S. Price, As. 4 or 5*d.*

"Some Diseases of Cattle in India. A Handbook for Stock-owners." Price, As. 8 or 9*d.*

"The Importance of Bacterial Action in Indigo Manufacture," by C. M. HUTCHINSON, B.A. Price, As. 2 or 3*d.*

SGPI—M—109 AAtoGofI—24-8-22—1,000

3 Copies

Bulletin No. 131 19

Agricultural Research Institute, Pusa

An Entomologist's Crop Pest Calendar for the Madras Presidency

BY

T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S.,
Assistant Entomologist, Madras.

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1922

Price, As. 2.

Edited by

The Council of the Pusa Agricultural Research Institute which is not, as a body, responsible for the opinions expressed in the Bulletin.

Agricultural Research Institute, Pusa

An Entomologist's Crop Pest Calendar for the Madras Presidency

BY

T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S.,
Assistant Entomologist, Madras.

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1922

Agents for the Sale of Books Published by the Superintendent of Government Printing, India, Calcutta.

IN EUROPE.

Constable & Co., 10, Orange Street, Leicester Square, London, W.C.

Kegan Paul, Trench, Trübner & Co., 68-74, Carter Lane, E.C., and 25, Museum Street, London, W.C.

Bernard Quaritch, 11, Grafton Street, New Bond Street, London, W.

P. S. King & Sons, 2 & 4, Great Smith Street, Westminster, London, S.W.

H. S. King & Co., 65, Cornhill, E.C., and 9, Pall Mall, London, W.

Grindlay & Co., 54, Parliament Street, London, S.W.

Luzac & Co., 46, Great Russell Street, London, W.C.

W. Thacker & Co., 2, Creed Lane, London, E.C.

T. Fisher Unwin, Ltd., 1, Adelphi Terrace, London, W.C.

Wm. Wesley & Son, 28, Essex Street, Strand, London.

B. H. Blackwell, 50 & 51, Broad Street, Oxford.

Deighton Bell & Co., Ltd., Cambridge.

Oliver and Boyd, Tweeddale Court, Edinburgh.

E. Ponsonby, Ltd., 116, Grafton Street, Dublin.

Ernest Leroux, 28, Rue Bonaparte, Paris.

Martinus Nijhoff, The Hague, Holland.

IN INDIA AND CEYLON.

Thacker, Spink & Co., Calcutta and Simla.

Newman & Co., Calcutta.

R. Cambray & Co., Calcutta.

S. K. Lahiri & Co., Calcutta.

B. Banerjee & Co., Calcutta.

The Indian School Supply Depôt, 309, Bow Bazar Street, Calcutta, and 226, Newabpur, Dacca.

Butterworth & Co. (India), Ltd., Calcutta.

Rai M. C. Sarcar Bahadur & Sons, 19/2A, Harrison Road, Calcutta.

The Weldon Library, 57, Park Street, Calcutta.

Standard Literature Co., Ltd., Calcutta.

hand & Sons, Calcutta.

Association Press, Calcutta.

Higginbotham & Co., Madras.

V. Kalyanarama Iyer & Co., Madras.

G. A. Natesan & Co., Madras.

S. Murthy & Co., Madras.

Thompson & Co., Madras.

Temple & Co., Madras.

P. R. Rama Iyer & Co., Madras.

Vas & Co., Madras.

M. R. Ry. E. M. Gopalakrishna Kone, Madura.

Thacker & Co., Ltd., Bombay.

A. J. Combridge & Co., Bombay.

D. B. Taraporevala, Sons & Co., Bombay.

Radhabai Atmaram Sagoon, Bombay.

Sunder Pandurang, Bombay.

opal Narayan & Co., Bombay.

Ram Chandra Govind & Son, Kalbadevi, Bombay.

Proprietor, New Kitabkhana, Poona.

The Standard Bookstall, Karachi.

Mangaldas Harkisan Das, Surat.

Karsandas Narandas & Sons, Surat.

A. H. Wheeler & Co., Allahabad, Calcutta and Bombay.

N. B. Mathur, Supt., Nazir Kanun Hind Press, Allahabad.

Munshi Seeta Ram, Managing Proprietor, Indian Army Book Depot, Juhi, Cawnpore.

Rai Sahib M. Gulab Singh & Sons, Mufid-i-Am Press Lahore and Allababad.

Rama Krishna & Sons, Lahore.

Supt., American Baptist Mission Press, Rangoon.

Manager the "Hitavada" Nagpur.

S. C. Talukdar, Proprietor, Students and Company, Cooch Behar.

A. M. & J. Ferguson, Ceylon.

Manager, Educational Book Depôts, Nagpur and Jubbulpore.*

Manager of the Imperial Book Depôt, 63, Chandney Chauk Street, Delhi.*

Manager, "The Agra Medical Hall and Co-operative Association, Ltd." (Successors to A. John & Co., Agra).*

Supt., Basel Mission Book and Tract Depository, Mangalore.*

P. Varadachary & Co., Madras.*

H. Liddel, Printer, etc., 7, South Road, Allahabad.*

D. C. Anand & Sons, Peshawar.*

Ram Dayal Agarwala, 184, Katra, Allahabad.*

Manager, Newal Kishore Press, Lucknow.*

* Agents for the Sale of Legislative Department publications only.

6.—AN ENTOMOLOGIST'S CROP PEST CALENDAR FOR THE MADRAS PRESIDENCY.

(Plate VII.)

By T. V. Ramakrishna Ayyar, B.A., F.E.S., F.Z.S., *Assistant Entomologist, Madras.*

It must be conceded that in any agricultural tract where sufficient experience has been gained of the behaviour of important crop pests over a fairly long period time, it might be possible for one to forecast the probable time of appearance of each pest during the different seasons of any normal year. Of course, many an Entomologist can easily recall the vagaries of different insects and quote instances of how an expected pest often deceives him by not showing itself and how it sometimes causes surprise by its sudden and unexpected appearance in another year. Apart from these abnormal and exceptional cases it may be found practicable to prepare a crop pest calendar* as a sort of rough forecast more or less on the lines of weather predictions. In spite of all the inevitable defects which such a calendar is bound to possess, it is believed that it might still serve some useful purpose in different ways. To the educated farmer, who is anxious to reduce the annual toll levied by insects on his crops, a knowledge of the probable time of appearance of important insect pests during a year will be a very valuable thing. For, in most cases of insect attacks, especially on field crops grown over extensive areas, preventive and precautionary methods go a great way in saving the situation. Therefore, it is apparent that such a knowledge will serve as a sort of warning to the farmer to be on the look-out for the pests and be prepared beforehand to take prompt measures the moment the pest makes its appearance or even just before it is expected to appear. To the Agricultural Entomologist this knowledge is much more. It gives him in addition, a clue to the seasonal habits of the different crop insects, their life cycles during the year, and a number of other interesting points in the biology of the various insects. It helps the official Entomologist of any Province not only to proceed to the different localities at the proper time to carry out investigations, but also to organize his campaigns against various pests sufficiently early and not be compelled to rush all

*The preparation of such pest calendars was discussed sometime ago between the writer and E. Ballard, Esq., B.A., F.E.S., Government Entomologist, Madras, and the author of this paper is indebted to Mr. Ballard for all encouragement in this direction.

unprepared when the pest has already appeared and done some appreciable mischief. It will also help him to pre-arrange the work of his staff which might often be insufficient and not available in time if some sort of time-table is not chalked out for them corresponding to the periods of appearance of the different crop pests. A calendar of this sort is not without its use to outsiders. To an outside Entomoloist who wishes to study particular pests of the Province the calendar might indicate to him the approximate time of the year when he could arrange to visit the *locality with* advantage; we know of some cases in the past when experts have rushed from one corner of the country to another and returned disappointed. And as to its utility to an Insect Expert coming fresh into the country with absolutely no experience of the local conditions, no one, I think, will have any doubts.

The attempt made in this paper at the preparation of a Calendar for South India is entirely based on past experience with, however, no pretensions to any completeness or mathematical accuracy.

It is now fourteen years since work in Agricultural Entomology was started in Madras on a scientific basis. As one of the officers engaged in this work from its very inception in Madras—in fact, as one engaged in Entomological work from the very next year after the first official Entomologist was appointed for the Government of India—I have had opportunities to gather information and acquire a fair amount of personal knowledge of the various agricultural tracts of the province from an entomological point of view, apart of course, from suffering the various disadvantages incidental to the lot of a pioneer worker on a subject quite new to the country. Though ten or fifteen years is nothing compared to the long periods necessary to get any thorough experience of entomological conditions of any tract, I think I may lay claim to some experience, however limited, on the subject of insect pests of the Province.

In any agricultural tract all crop pests, at any rate insect pests, may be conveniently divided into three groups from the point of view of their seasonal occurrence. Under the first group might be included all those insects which appear on crops during regular seasons year after year causing sometimes less and sometimes serious damage. These are generally the major pests of the important staple food and industrial crops of different kinds. In Madras these constitute the important insect pests of crops like paddy, sorghum, millets, pulses, cotton, sugarcane, gingelly, groundnut, castor, tobacco, mango, etc.

The second group might be made to include certain insects which are generally of minor importance and occasionally found in small numbers but which only in certain years become sporadic serious local

pests ; these appear on a variety of cultivated crops. As examples of these we have in Madras blister beetles of sorts, surface grasshoppers and locusts, surface weevils, climbing cutworms, tussock moths, slug caterpillars, etc.

The third group comprises those insects found all the year round without any marked seasonal variations in their appearance. These are generally found on perennial crops like palms, fruit trees, vegetables and garden shrubs ; some of them also infest stored products and household materials. Familiar examples of this group are the palm beetles, white ants, rice weevil, meal worm moths, silver fish, etc.

Of these three groups we may leave out of consideration in this paper the third group, as the insects under it do not exhibit any striking periodical or seasonal variations and as such are outside the pale of a regular calendar. Taking the first two groups we may consider the periodical activities of the important insects under each heading and see what place they occupy in the insect calendar.

In considering the periodicity of crop pests in any tract one has always to remember that the climatic and agricultural conditions of a particular area have a great deal to do with the appearance or absence of any pests. Unlike some of the other provinces of India we in the South (see map) have several distinct agricultural tracts each possessing distinct climatic and agricultural practices of its own ; and naturally the crop seasons vary a good deal in the different tracts, the same crop having its own appropriate time in the year in the different regions. We have the West Coast area with its unfailing heavy rains (over 100 inches) chiefly during the South-west monsoon season from June to September ; there are the Northern Circars including the big deltas which are irrigated by the rivers Godavari and Kistna ; next the Carnatic Districts along the Coromandel Coast which get the greater part of their rainfall during the North-east monsoon season from October to January. Further down, we have the four southern districts of Tanjore, Madura, Ramnad and Tinnevelly with an average rainfall of not more than 33 inches for the tract, and which mostly depend on irrigation facilities for their important crops ; and then we have the Deccan and southern tablelands with a scanty and capricious rainfall. This being the case one and the same insect affecting a particular crop appears in the different areas in different seasons. Keeping the above facts in view I have designed two or three diagrams wherein I have tried to show at a glance the periodical appearance of the important insect pests during any normal year.

To explain the seasonal distribution of the insects of the first group I have prepared two diagrams, a circular and tabular one. The former

is devoted to show the periodicity of the chief pests of the paddy crop alone, this being the most important staple food crop of the province and grown over a greater area than others. This diagram (Plate VII) represents nine concentric circles divided off into twelve parts to show the months of the year. The idea is to represent the periodical occurrence of about ten important paddy insects, which I have selected during the months of the year; each insect is allotted one of the nine circles and the time of its appearance shaded within its orbit. It may be stated at the outset that stray examples of almost all the common insects affecting paddy are generally found here and there throughout the year, but in every tract there is a particular season at which each insect often assumes pest proportions; and it is that particular period or periods of the year that I have attempted to indicate in the diagram. A casual glance at the diagram apparently shows that the paddy entomologist in Madras has work all through the year, but his busiest time appears to be from September on to February. Just a word or two to supplement the information that may be gathered from the diagram itself, may not be out of place here. The swarming caterpillar (*Spodoptera mauritia*) which is allotted the outermost circle in diagram No. 1 appears twice in the Northern Circars, *viz.*, at the beginning of each crop in June-July and January February, and often causes considerable damage to the nurseries. The next important tract where it is found is along the West Coast where it appears just before the South-west monsoon Rains and is equally destructive in certain years. During abnormal years the pest is reported from other tracts beyond the usual season. The paddy stem-borer (*Schoenobius bipunctifer*), No. 2 in diagram, is a regular visitor during the autumn and cold weather chiefly in the Northern Circars; it has, however, been very rarely noted to do such wholesale damage as the swarming caterpillar. It is occasionally bad during the summer months in the Ceded Districts. Within the past three or four years the disease called '*Yerra tegulu*' or red disease has been noted in the delta tracts of the Godavari and Kistna districts and has been mistaken to be the sole work of this insect. Recent investigations have shown that besides the stem-borer there are two other agencies at work, *viz.*, a leaf-spot fungus and another unknown disease associated with what at present appears like an eel worm*, both together doing far more harm than the paddy stem-borer insect. The leaf-mining beetle of paddy, popularly known as the "Rice Hispa" (*Hispa armigera*), No. 3, may be taken as the next important insect affecting paddy. During the South-west monsoon

* The eel-worm is being studied by Mr. Ballard, the Government Entomologist, Madras.

months the insect is particularly bad in Malabar and South Kanara and later on in the irrigated central districts ; and in the Coromandel tracts it is found later. In South Kanara the pest is particularly bad and even does damage to the summer crop of paddy in February-March. In company with this beetle is often found the smooth greenish-blue beetle (*Leptispa pygmœa*), No. 4, which does appreciable damage in parts of Malabar from August to November. Next I have taken the Rice Bug (*Leptocorisa varicornis*), No. 5, the active paddy grain sucker. Though found all over South India periodical reports are received only from the West Coast tracts, especially from the villages along the Western Ghats. The case worm, *Nymphula depunctalis*, No. 6, is bad in Malabar and South Kanara during September to November and in the early summer months. The paddy grasshopper, *Hieroglyphus banian*, No. 7, like the rice bug, has a wide distribution in the province but assumes pest proportions only in particular tracts during certain seasons. In the West Coast, Tinnevelly and in the Mysore Ghat tracts it appears with the South-west monsoons and in the Circars during the later months. The Silver-shoot disease, *Kodu* or *Anaikombu*, *Pachydiplosis oryzæ*, No. 8, is bad in the Northern Circars from August to December during certain years. The paddy mealy-bug, the 'soorai' disease, *Pseudococcus sacchari*, No. 9, is found in the central districts during the cold weather. Thrips of paddy, which comes last among the paddy insects I have selected, *Bagnallia oryzæ*, No. 10, and which does some damage to very young paddy, is occasionally bad in Malabar, Chingleput and Coimbatore, especially when the usual expected showers are not received.

The second diagram, which I have prepared, shows the seasonal distribution of the important insect pests of other crops besides paddy and is a tabular one. Here I have only taken the most important of the numerous insects so far noted and especially those which display striking periodical activity. The most important of these insects which give trouble almost every year are the hairy caterpillars of dry crops, the castor semi-looper, the mango-hopper, caterpillars and plant lice of tobacco, the groundnut leaf-miner, the stem weevil, plant lice and boll worms of cotton, the gram caterpillar, the cholam ear-head bug, the gingelly caterpillar, the sann-hemp caterpillars and sugarcane borers. The hairy caterpillar (*Amsacta albistriga*) is particularly bad in the central districts, South Arcot and parts of the Ceded Districts from June on to October and attacks almost all dry and garden crops, such as *sorghum*, *cumbu*, groundnut, ragi, cotton, etc. The semi-looper (*Achœa janata*) is very destructive to castor in the Ceded Districts from October to December and later on in Salem and Coimbatore. The Mango Hoppers (chiefly

into India and therefore advised the adoption of measures against its spread. Its occurrence on the Chinsurah Farm, where it was found breeding in three fully-grown canes growing in a clump, the canes being practically dry and showing characteristic holes emitting dust in their basal joints, indicates that this shot-hole borer may perhaps prove to be an occasional pest of cane, possibly more frequently than has been noted by us. In *Indian Museum Notes*, Vol. V, p. 74, it is recorded as having been found in cane in numerous districts in Bihar and Bengal. *X. perforans* is widely distributed in India and Burma and has been recorded as boring in *sal* (*Shorea robusta*), *Anogeissus latifolia* and *Areca catechu*." (*Imperial Entomologist's Annual Report for 1919-20*).

The Flea Beetle Borer (C. S. No. 1891, 1923 and 2043).

(Plate XXV, fig. 1.)

Foodplants—*China* (*Panicum miliaceum*).
Rice (*Oryza sativa*).

Grubs of this beetle have been observed from about April to August to bore into the stems of paddy seedlings and young *China* plants from the side near about the ground level. After gaining access into the stem they bore up and down the centre to some extent, filling the tunnel with pellets of excreta and causing " dead heart " characteristic of all internal borers. The full-grown grubs leave the stems and pupate underground, emerging as adults after six to seven days. It is not known where eggs are laid but from the habits of the larva it appears that they are deposited somewhere near or on the surface of the ground. The periods of egg and larval stages are also unknown. From observations however it seems that the lifecycle is completed in about three weeks. The adult beetles nibble the tissue from the surfaces of leaves as all flea beetles are ordinarily observed to do.

The grubs are observed to occur in large numbers in July and August and rank as a pest. They however occur in highland loamy soils and will be observed to infest millets and varieties of paddy which can be grown in such dry lands.

The full-grown grub (which resembles the young grub in appearance) is about 4 mm. long and about 0·75 mm. across the body which is semi-cylindrical in shape being slightly compressed in the dorsoventral plane. The head, the prothoracic and anal plates and the three pairs of thoracic legs are dark grey or almost black in colour and their surfaces somewhat glossy. The prothoracic plate is divided by a faint longitudinal line which is visible under lens. The general colour of the body is pale yellow which deepens to some extent before pupation. The hairs on the body are small and they arise from small somewhat glossy grey

Idiocerus niveosparsus) are often very destructive to blossoms early in the year from January to March, chiefly in the important mango tracts of Salem, Bangalore, Chittur and Vizagapatam. The 'Plant Lice' pest on tobacco is an important one from December to April in Guntur, Coimbatore, Madura, Ramnad, Tanjore and South Kanara; the leaf caterpillar and stem-borer are often reported from the 'Lankas' in Godavari during the cold weather. The groundnut leafminer "*Surul puchi*" (*Stomopteryx nerteria*) causes appreciable damage to the ground nut crop, especially when the rain-fed crop is on the ground from September to November in the two Arcots and Trichinopoly. The cotton pests are chiefly noted in the Coimbatore and Tinnevelly tracts during the cotton season from October to May. The ear-head bug of cholam (*Calocoris angustatus*) is special to the Coimbatore and Bellary districts during June-July and sometimes in the cold weather also. The Slug caterpillar (*Parasa lepida*) which appears on a variety of plants like castor, mango, palms, etc., is chiefly noted during the months from October to January and in certain years causes serious damage. I do not think any special remarks are necessary for the other insects and their distribution may be gathered from the diagram itself.

Coming to the second group of pests which, as I said before, includes insects of minor importance occasionally found in small numbers, but which appear as sporadic local pests only in certain years, I have added another diagram. Such insects are few in number and during normal seasons they are practically of no importance at all. On our knowledge and experience of insect pests in South India, about ten insects may be brought under this head as displaying the remarkable habit of abnormally multiplying and appearing suddenly only in certain years. The climbing cut-worm of paddy (*Cirphis albistigma*) may be taken as a good example. During some years when the rainfall is unusually heavy and the fields are flooded during the North-east monsoon months on the Coromandel Coast, this pest begins to appear and often assumes serious proportions during January-February, thousands of caterpillars being found cutting down the ripening ear-heads. For three or four years in succession from 1912 there was the locust plague in the Ceded districts during the months August-November caused by the Deccan grasshopper (*Colemania sphenarioides*) attacking all dry cereals of the tract. Fortunately, for the past two or three years, it has not been reported serious. Of the others, the chief are the black hairy caterpillar (*Amsacta lactinea*) on *ragi* and *cholam* in Coimbatore and Salem during August-September, the Surface weevil (*Atactogaster finitimus*) found on young cotton in Tinnevelly during November, Blister beetles of sorts (*Lytta*, *Epicauta*, spp.) attacking *cumbu*, *cholam*, etc., in October-November, the Hawk

moth caterpillar (*Herse convolvuli*) on green gram in the Circars during the cold weather, the green plant bug (*Nezara viridula*) on *cumbu* in Tinnevelly in November-December, grasshoppers (*Catantops* sp.) on cotton in Ramnad in December-January, surface grasshoppers (*Aiolopus* spp.) on cereals in Coimbatore and Ramnad in August-September and Tussock moth caterpillars (*Euproctis*, *Orgyia*, spp.) on red gram and castor during the cold weather.

I have thus tried to give an idea, however incomplete, of the periodical occurrences of the most important insect pests of South India by dividing them into three more or less convenient groups, and I have attempted to convey as much information as possible in the diagrams which illustrate this paper. I believe, as our knowledge and experience increase, it might be possible to amend this calendar in the light of new observations, and make it far more accurate and complete than it is at present. Till then I venture to believe that this calendar might serve some useful purpose.

In conclusion, I am of opinion that if such calendars are prepared for the different provinces they will be found not only useful in themselves, but, taken as a whole, will give one a fund of information on the distribution, seasonal variation and food habits of some of the important crop-pests which are common to all tracts of the Indian Empire.

INDIGO PUBLICATIONS

No. 6. The Effect of Manuring with Superphosphate and Sannai on the Yield of Crops on Indigo Planters' Estates in Bihar—especially of Rabi Crops in the Season 1918-1919, by W. A. DAVIS, B.SC., A.C.G.I. Price, As. 6.

No. 7. The Conditions affecting the Quality of the Java Indigo Plant (Leaf yield and richness of the leaf in indigotin), by W. A. DAVIS, B.SC., A.C.G.I. Price, As. 9.

No. 8. Note on the Development of the Indigo Industry in Assam in Conjunction with Tea and other Crops, by W. A. DAVIS, B.SC., A.C.G.I. Price, As. 3.

No. 9. The Nature of the Changes Occurring during the Extraction of Indigo from the Java Plant (*Indigofera arrecta*), by W. A. DAVIS, B.SC., A.C.G.I. Price, R. 1.

No. 10. Note on the Deterioration of Indigo Seed during Storing, by Major W. R. G. ATKINS, SC.D. F.I.C. Price, As. 3.

BOOKS

"Wheat in India," by ALBERT HOWARD, M.A., A.R.C.S., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. 288 pp. Price, Rs. 5 or 7*s.* 6*d.*

"A Description of the Imperial Bacteriological Laboratory, Muktesar: Its Work and Product," by MAJOR J. D. E. HOLMES, M.A., D.SC., M.R.C.V.S. Price, As. 8 or 9*d.*

"Agriculture in India," by JAMES MACKENNA, M.A., I.C.S. Price, As. 4 or 5*d.*

"Some Diseases of Cattle in India. A Handbook for Stock-owners." Price, As. 8 or 9*d.*

"The Importance of Bacterial Action in Indigo Manufacture," by C. M. HUTCHINSON, B.A. Price, As. 2 or 3*d.*

SGPI—M—330 AA to G of 1—10-6-22—009

24

IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH

Household Insect Pests and their Control

BY

MOHAN SINGH, M.Sc.

Reprinted from

INDIAN FARMING

Vol. II, No. 5, May 1941

PUBLISHED BY MANAGER OF PUBLICATIONS, DELHI

PRINTED BY MANAGER, GOVERNMENT OF INDIA PRESS, CALCUTTA

HOUSEHOLD INSECT PESTS AND THEIR CONTROL

By Mohan Singh, M.Sc.

Assistant to the Imperial Entomologist, New Delhi

THE cockroach is a cosmopolitan pest. Cockroaches are quite common in houses in northern India, but the damage they do is relatively small. Their presence, however, is very objectionable and annoying. In Bihar, Bengal and other parts in which the climate is comparatively hot and moist, they do considerable damage and are therefore considered as among the worst domestic pests.

Several species of cockroaches occur in India, *Periplaneta americana* L. (Fig. 1) being the most common. This cockroach is distributed almost all over the world. The other common species in this country is *P. australasiae* Fab. (Fig. 2) which is confined almost only to southern India and Ceylon. *Blatta orientalis* Linn. and *Blatta germanica* Linn. and *Stylopyga rhombifolia* Stoll. are also likely to be found in some parts of India.

The cockroach: description

Cockroaches are flattened insects, with horny, smooth and slippery bodies and large spiny legs for fast running. Their colour is generally brown or dark brown. The head is inflexed under the body and the antennae or feelers are long and slender. The mouth parts are well developed and include strong biting jaws which enable these insects to eat all kinds of food. They are omnivorous insects feeding on almost any dead animal matter, cereal products and all sorts of provisions. Their favourite food is starchy material, such as bread and biscuits, and they do not spare the paste used in binding books, which consequently get badly damaged and disfigured.

They live in dark places hidden in cracks and crevices, in kitchens and pantries, under boxes or in cupboards. They are seldom seen during the day and come out mostly at night when they prowl about and do the actual damage. Heat, moisture, darkness and plenty of starchy food are ideal conditions for their breeding.

Cockroaches give out, wherever they occur in some numbers, a fœtid, nauseous odour, well known as 'roachy odour' which is persistent and cannot be removed from shelves and dishes without washing them with soap and boiling water. Foodstuffs are unpleasantly tainted beyond redemption.

Life-history

The life-history of almost all the species named above is generally similar in essential features. Cigar-shaped eggs are laid in small bean-shaped capsules inside which they are arranged in two longitudinal rows (Fig. 3). The number of eggs in a capsule varies in different species.

The eggs hatch in about two days during summer, but in winter the incubation period may be several weeks. The freshly hatched young ones are often kept together by the mother and brooded over and cared for. These young cockroaches or nymphs (Fig. 4) pass through a variable number of moults or change of skins, as they grow. After some time their wings start developing, but they do not acquire full size till the individuals become adults. The period which elapses between the hatching of nymphs and their reaching the adult stage is variable, depending upon the climatic conditions and food supply. Generally there is only one generation in a year.

The abundance of roaches is, therefore, not so much due to the rapid rate of multiplication but because of their being able to preserve themselves from ordinary means of destruction. Their flattened bodies enable them to get entrance through very narrow cracks and crevices to take shelter against the attack of enemies.

Control methods

Scrupulous cleanliness of the kitchen, pantry,

dining room, and keeping them free from unused and polluted foods and other refuse go a long way in reducing the number of these insects. For this reason all the remains after meals must promptly be removed to proper containers.

A variety of measures are advocated for the control of cockroaches and many proprietary substances in the form of sprays are reported to be effective in killing them. The best results have been secured by the use of commercial sodium fluoride, used in full strength or mixed with equal parts of flour. With the help of a dust gun or blower sodium fluoride can be thoroughly dusted over shelves, tables, floors and the runways and hiding places of the roaches. Its action is slow but sure as it gets stuck to their feet and from these gets into their mouths and so poisons them. However, good care should be taken not to let the poison mix with human food. It is, therefore, advisable to add a colour to the powder so as to distinguish it from other powders in the kitchen and pantry, such as baking powder.

Borax is also used in a similar way, but it is not so effective as sodium fluoride.

A mixture of one part of pyrethrum powder and four parts of sodium fluoride is very effective and acts more quickly than the pure fluoride but it is comparatively expensive.

Effective baits

Baits prepared in the following way have been successful in killing the large American roach :

Cotton-seed meal or linseed meal	1 pint
Molasses	3 tablespoonfuls
Water	Enough to make a thin paste

The mixture is cooked for a short time and allowed to stand until cool. A yeast cake dissolved in a cup of water is then added and stirred. It is allowed to stand in a warm place for about 12 hours in order that fermentation may get well under way. Then a teaspoonful of lead arsenate is stirred in.

This is ready now to serve and it should be placed in shallow containers used for no other purpose.

Since cockroaches are nocturnal in habit, this bait should be put out in the evening. The arsenate of lead should not be added to the bait until just before it is put out for the roaches. Bait made according to this formula is satisfactory as long as it remains in a semi-liquid or moist state. When the paste finally dries down it should be moistened and used again. It is most attractive to roaches when fermentation is at its height, gradually losing its attractiveness as the fermentation decreases.

Fumigation

Fumigation with hydrocyanic acid gas is very effective, but the gas being the most deadly of the fumigants has to be handled with great care. It is generated in several ways and has a wide variety of applications. However, it should not be used except under the supervision of an expert because of its dangerously poisonous nature.

Calcium cyanide, under the names 'cyanogas' or 'calcyanide' in the form of powder or flakes, which also gives out hydrocyanic acid gas, has great advantages. It can be handled more safely. It gives off the gas in the presence of atmospheric moisture so that it is necessary merely to expose it to generate the gas.

This powder is very useful. A little quantity of this powder blown into infested places acts very quickly. It gives off hydrocyanic acid gas which readily kills cockroaches. Two treatments with this material at an interval of a week or ten days gives complete kill in many cases. The dead individuals should be swept up immediately and burned, because cockroaches often recover from cyanide poisoning if the dose of the gas is not strong.

Carbon bisulphide fumigation is also recommended. Although many roaches may be killed, a large number of them usually escape from the house before the gas becomes strong enough to kill them.

The common sulphur powder dusted about the places where cockroaches abound has also been reported to be a very good repellant for this pest.

Various forms of traps have been successfully employed in England and on the continent of Europe. These devices are so contrived that the roaches can easily get into them but cannot come out. The entrapped individuals can be quickly killed by immersion in hot

water, etc. No good trap has yet been designed for use under Indian conditions.

The house cricket

Every householder is familiar with crickets, dull, straw or brown-coloured insects having black patches on the head and thorax. Crickets generally abound in cupboards and in the folds of hanging clothes. They are generally over an inch long and have long feelers (Fig. 5). The wings are deflexed and lie flat over the body when at rest. The extremity of the abdomen is provided with two long, slender appendages, and in the case of the female there is in addition a long and fine ovipositor with the help of which eggs are laid. Of the three pairs of legs, the hind legs are much bigger and are well suited for jumping.

In northern India there are two species commonly found in the house, viz. *Gryllulus domesticus* L. and *Gryllus sigillatus* Wlk. (Fig. 6). *Gryllulus domesticus*, popularly known as 'European house cricket', is also capable of damaging cultivated crops in the field. *Gryllus sigillatus*, however, is chiefly a species confined to the house and the damage done by this cricket is sometimes enormous.

Omnivorous habit

Like cockroaches, crickets are omnivorous insects. They feed especially on woollen and artificial silk fabrics, rendering them entirely unserviceable. Clothes damaged by them are so disfigured that they cannot be mended and used again. They also like starchy food such as bread, cakes, biscuits and flour, and like roaches damage books, especially their bindings, by eating away the glue or paste.

In some other habits also they are similar to cockroaches. They are seldom seen during the daytime, when they remain hidden in cracks and crevices, behind hanging clothes, wall-papers, pictures, etc. They thrive best in damp and warm places such as those in the kitchen. Parts of the house which are less frequently disturbed also become their favourite haunt.

They are found throughout the year but are especially active during the rainy season. Crickets are capable of living and breeding outside the house, especially under refuse dumps or in the gardens. With the onset o winter they migrate into the house where it i warmer. As regards *Gryllulus domesticus* L., i seems to breed always outside the house becaus only adults are found in the house while al the younger stages are seen in the field.

There is usually one complete generation in a year.

The female cricket lays eggs in clusters of about 30 eggs each. They are more or less cylindrical in shape and yellowish-white in colour. The young or the nymphs that hatch out of the eggs are in general shape similar to the adult except that they have partially developed wings. It takes about three months for the nymph to reach maturity, but this period may be longer under cooler and drier conditions. Both the young and the adult do the damage.

Control measures

Liberal sprinkling of naphthalene flakes in trunks, wardrobes and other places infested or likely to be infested by crickets will save the clothes from attack. A mixture of equal parts of finely powdered sodium fluoride, flour and sugar put in small trays in the places frequented by crickets is also very useful.

Crickets can also be controlled with poison baits made up as follows:

Lead arsenate or Paris green or Sodium fluosilicate	2 chattaks
Wheat bran (*chhan*)	2½ seers
Molasses	½ seer
Salt	1 tola

The ingredients are mixed together and moistened with about one seer of water. Frequently attractants, such as chopped whole oranges or lemons or essence of banana or amyl acetate, are added in small quantity to give flavour to the bait. Small quantities of the bait may be placed in shallow pans near the infested places. It can also be spread out in the gardens near the refuse dump or other places where the crickets breed. The bait must be spread only after dusk and when fresh and moist. What is left over by the next morning is useless and unattractive. It is always better if the bait is

prepared fresh before it is actually laid in dishes. The operation may be repeated after a fortnight or so for about three or four evenings.

The above bait is very poisonous, and therefore children and domestic pets should not be allowed to touch it.

The cracks and crevices in which the crickets may hide themselves should be as far as possible located and cemented permanently. If it is possible to locate their breeding holes, they can be treated with a fumigant as is recommended in the case of the cockroach. Even boiling water poured into such breeding holes will kill them.

Several proprietary preparations containing pyrethrum available on the market are reported to be effective. Such preparations are often very expensive. Moreover, since pyrethrum loses its insecticidal value rapidly both from exposure and with age, such insecticides cannot be regarded as reliable killers unless they have been prepared and preserved properly.

The silverfish insect

In common with other household insects these creatures are well distributed throughout the world. They are known by a variety of names of which the following are perhaps the most familiar ' Silverfish ', ' Silvermoth ', ' Sugarlouse ', ' Sugarfish ', ' Fish moth ', ' Slicker ' and ' Bristle-tail '.

The silverfish belongs to the most primitive group of insects and the species commonly met with is *Lepisma saccharina* Linn. (Fig. 7).

It is about one-third of an inch long, with the body tapering from the head to the tail end and is clothed with glistening silvery scales, which give the body a uniformly silvery-grey colour. The silverfish belongs to that class of insects (*Thysanura*), the members of which never acquire wings at any stage of life. There are two long, slender, many-jointed feelers or antennae projecting forward from the head and three long tail-like appendages extending backwards from the hind end. The mouth parts are better suited for scraping than for chewing purposes. The protective colouration of the insect, the rapidity with which it moves and the fact that the body is soft make it almost impossible to capture a specimen without crushing it.

They thrive in dark, moist places, shunning light, dry and well ventilated places. They feed either on vegetable or on animal matter, such as starch, glue, heavy-sized glazed paper, paste, etc. Their preference seems to depend largely upon the nature of food supply early in life. If they have habitually fed on starch they will maintain a steadfast preference for starch and will starve rather than feed on glue or any other material. Books left undisturbed for a long time in damp, dark places are readily liable to become infested, but those in frequent use often remain free from this pest. The silverfish also collect behind wall-paper and literally eat it off the wall by removing the paste used to fix it.

There are a number of ways by which silverfish may get into dwellings. Usually they are dependent upon infested material or containers used for transportation. Household goods, stored in warehouses, under ordinary temperatures, are liable to infestation and serve as an ideal means of distribution.

The life-history of silverfish is very simple. Each female usually lays 7 to 12 small, whitish eggs, in crevices and other concealed places. They hatch in 6 to 10 days and the tiny young ones generally resemble the parent, except in size. The development is completed in about nine months during which period the individual casts 6 to 7 moults. In temperate climates it may take as long as two years to reach maturity.

Control measures

Ordinary house cleaning and ventilation will keep their numbers down. The silverfish, like crickets, can be controlled by dusting their haunts with a mixture of one part of sodium fluoride and eight parts of flour. Powdered borax is nearly as effective as sodium fluoride, when dusted in their runways and hiding places, but it is slow in action. Borax has, however, the advantage over sodium fluoride in that it is almost non-poisonous to man and higher animals and it retains its killing quantities indefinitely.

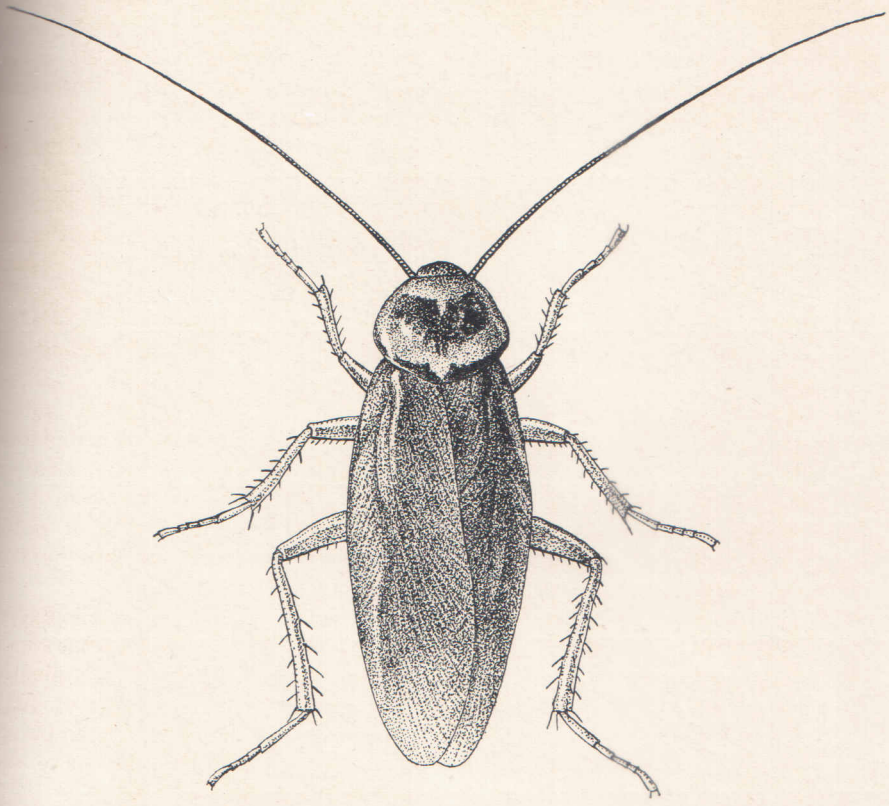


FIG. 1. *Periplaneta americana* L. (Adult stage) $\times 1\frac{1}{2}$

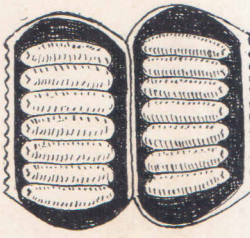


FIG. 3.
Egg-case with two longi
tudinal rows of eggs $\times 3$

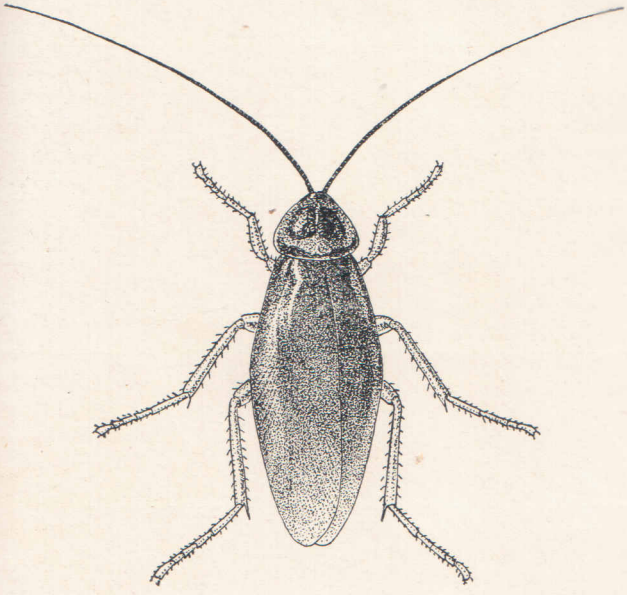


FIG. 2. *Periplaneta australasiae* Fab. (Adult stage) $\times 1\frac{1}{2}$

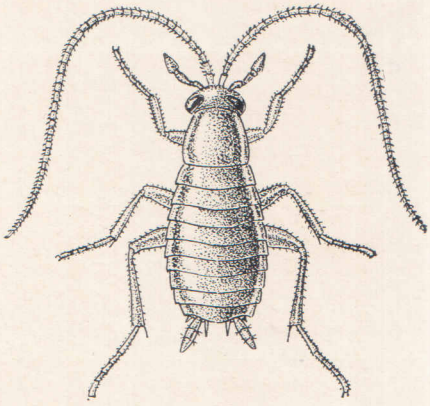


FIG. 4.
II instar nymph of *Periplaneta americana* L. $\times$

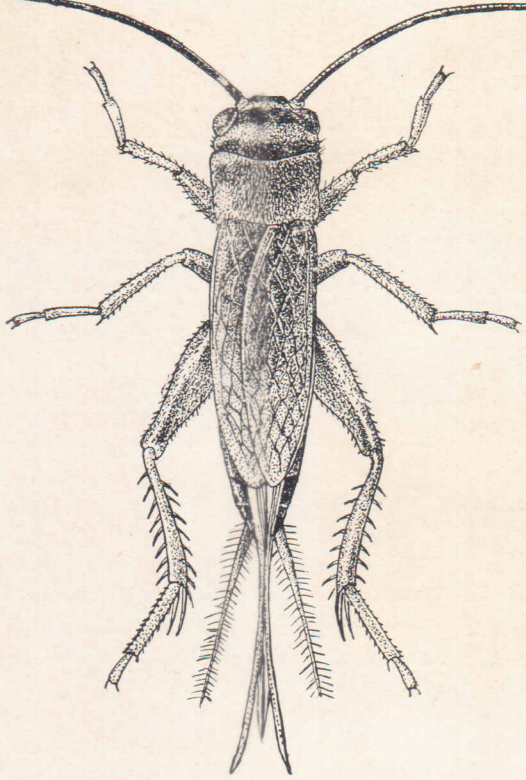


FIG. 5.
Gryllulus domesticus L.
(Adult stage) ×3

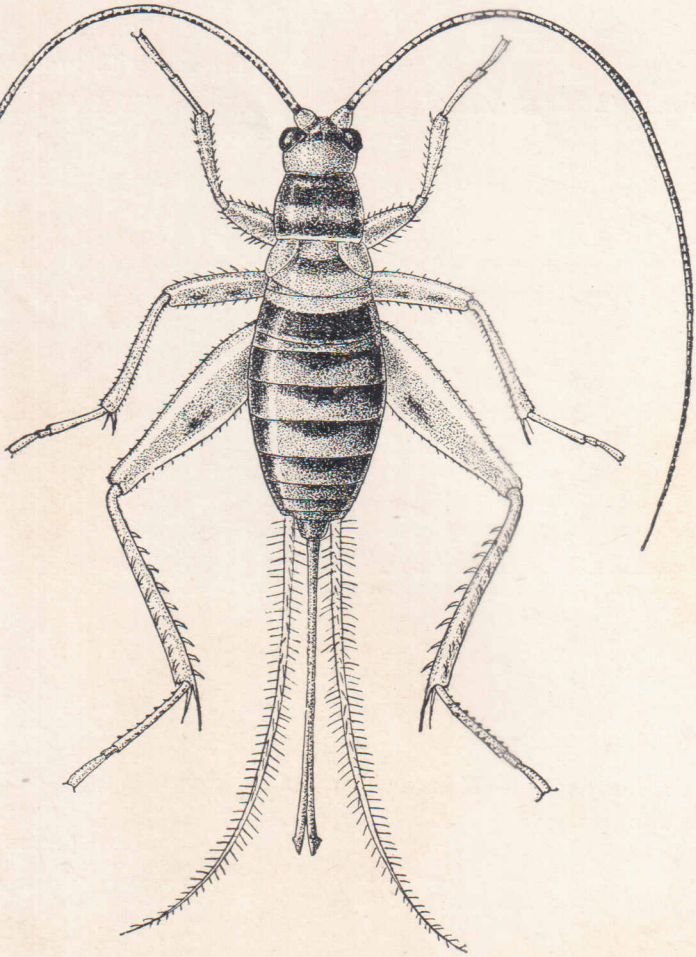


FIG. 6. *Gryllus sigillatus* Wlk. (Adult stage) ×6

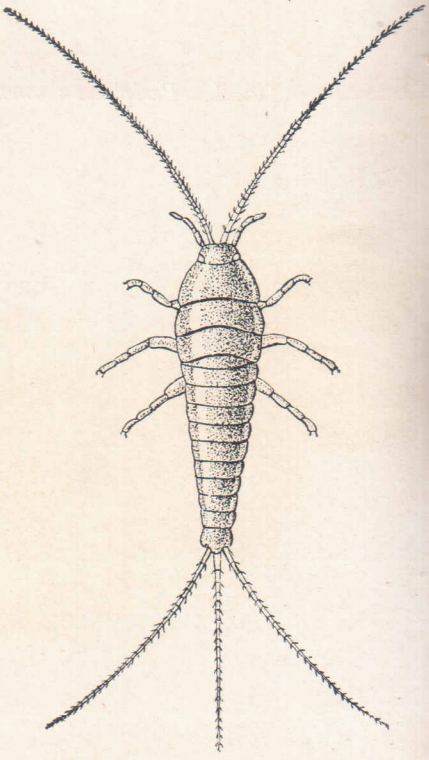


FIG. 7. *Lepisma saccharina* Linn. ×6

patches which make the grub look spotted. The tubular anal process on the underside of the anal segment is made use of in locomotion. The spiracles can be hardly distinguished but a white tracheal tube is visible faintly under the skin running along the spiracles. The pupa is white, about 2·5 mm. long and roughly broadly oval in shape with the lobes of legs, antennæ and wings free. The beetles are black.

Chrysomelid beetle (C. S. 1640).

(Plate XXIV, fig. 2.)

The larvæ of this beetle were collected in large numbers from sugarcane fields at Pusa in July, August and September. The pupal stage at this time was observed to be about five days.

Aphodius (C. S. 959, 1290, 1350, 1327).

Grubs were collected among *mootha* roots at Pusa in May and June 1915 which hibernated and attained adult stage in February 1916. Larva collected from harvested field on 29th February 1916, pupated on 2nd March and attained adult stage on 8th March.

From pupæ collected from cane field on 6th September, beetles emerged on 10th September and again from pupæ collected on 17th September, beetles emerged on 25th September.

For details of life-history of the other beetles and weevils mentioned in the paper "An Annotated List of Indian crop-pests" by T. Bainbrigge Fletcher, in the *Proc. of the Third Entl. Meeting*, may also be referred to.

Damage to rice.

As mentioned in the first paper the damage by borers to rice in the neighbourhood of Pusa does not ordinarily exceed about 4 per cent. Examination of stubbles at Chinsurah, Midnapur and Bankura in Bengal and at Cuttack in Bihar and Orissa did not show a higher percentage of damage.

I have taken up the question of rice stem borers in Burma and will be in a position to give very definite results at the next Meeting. It would be well if the work were taken up in all the rice-growing Provinces. Then we want to know the borers which can be actually held responsible for the damage. Detailed descriptions of the borers working at Pusa are given in the first paper.

The small amount of work done at the few places in Bengal mentioned above proved *Schœnobius bipunctifer* and *Chilo simplex* to be the principal agents.

THE IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH

Insect Pollinators of *Toria* (*Brassica napus* Linn. var. *dichotoma* Prain) and *Sarson* (*B. campestris* Linn. var. *sarson* Prain) at Lyallpur

BY

KHAN A. RAHMAN

Reprinted from

The Indian Journal of Agricultural Science

Vol. X, Part III, June, 1940

PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI.
PRINTED BY THE MANAGER, GOVERNMENT OF INDIA PRESS, NEW DELHI
1940

INSECT POLLINATORS OF *TORIA* (*BRASSICA NAPUS* LINN., VAR. *DICHOTOMA* PRAIN), AND *SARSON* (*B. CAMPESTRIS* LINN., VAR. *SARSON* PRAIN) AT LYALLPUR

INSECT POLLINATORS OF *TORIA* (*BRASSICA NAPUS* LINN., VAR. *DICHOTOMA* PRAIN), AND *SARSON* (*B. CAMPESTRIS* LINN., VAR. *SARSON* PRAIN) AT LYALLPUR

BY

KHAN A. RAHMAN, B.Sc. (EDIN.), PH.D. (CANTAB.), F. R. E. S.

Entomologist to Government, Punjab, Agricultural College, Lyallpur

(Received for publication on 2 November 1939)

INTRODUCTION

A number of economic plants (e.g. red clover, Cucurbitaceæ, some of the Brassicæ, apple, etc.) depend entirely upon insects for pollination [Waite, 1895, '99; Treherne 1923; Williams, 1925]. An increase in the population of such insects results in a material increase in the yield of the crop [Alderman, 1918; Auchter, 1922; Farrar, 1931].

In India this fruitful line of investigation has remained practically untouched. Apart from Burkill's random notes [1906-09, 1911], Ali Mohd. *et al's* [1931] and Ali Mohd.'s [1935] articles are the only contributions to the subject. The reason for this neglect is not far to seek. Economic Entomologists have been, and are still, busy combating injurious insects to realize the full significance of this branch of their subject, the importance of which to a pre-eminently Agricultural country like India, cannot be over-emphasized. It is, therefore, reasonable to maintain that a more intimate and comprehensive knowledge of insect visitors to the flowers of our plants of economic importance is long overdue.

OBJECTS OF THE PRESENT INVESTIGATION

Apropos of the record low yield of *toria* during 1928-29 in the Punjab Afzal Husain [1930] made the following observation: 'The last *toria* crop failed, and it was noticed that although the number of pods per plant was fairly large, the number of seeds per pod was very little, which shows defective pollination. As this crop is pollinated by insects, it seems likely that on account of certain unknown causes insects pollinating *toria* were not present in large numbers. It is a well known fact that insect pollinators play a most important part in the economy of nature and the question is so important that it cannot be ignored much longer.'

The work on insect visitors to *toria* and *sarson* flowers was, therefore, begun in January, 1930, at Lyallpur with a view to determine: (1) the species of insect visitors and their importance as pollinating agents, and (2) the relative significance of the important pollinators. This information was considered an essential preliminary for the elucidation of those 'unknown causes' which retard insect activity.

THE SPECIES OF INSECT VISITORS TO *TORIA* AND SARSON FLOWERS AND THEIR IMPORTANCE AS POLLINATORS.

Method of study.—The insect visitors to *toria* and *sarson* flowers were collected* for about 131 days i.e. from November to February, 1930 and 1931, in the Botanical Experimental Farm, Lyallpur. Collections were started almost immediately after the flowers appeared and were usually made between 12 noon to 3 P.M.—the period of greatest insect activity—for an average of 2·17 hours a day.

Weather conditions during collection period.—Excepting eight days†, when the prevailing weather conditions were not favourable, the remaining 123 days, particularly during the collection period, had ideal conditions for insect flight and activity. Table I gives the meteorological data which was found favourable for insect flight during *toria* and *sarson* seasons in 1930 and 1931.

Insect visitors.—The collections made include 105 different species representing 55 families of 9 orders of the Class Insecta. The importance of these insects as pollinating agents is discussed below.

ORDER HYMENOPTERA

Fam. APIDAE.—*Apis florea* Fab. is the only representative of this family secured from *toria* and *sarson* flowers. Table II gives the numbers collected from the two crops during the specified weeks.

It is seen from the above table that *Apis florea* Fab. is slightly more abundant in *sarson* than *toria*. It begins to desert this crop for other flowers towards the end of February.

The nesting habits of *Apis florea* Fab. are described by Ghosh [1915].

This bee works zealously and enthusiastically 'during bright, sunny, warm weather', when there is slight or no wind. During inclement weather it does not leave its hive. When overtaken by bad weather during work it immediately suspends its activities and clings to the flower. In this condition it allows itself to be picked up by hand without stinging.

Apis florea Fab. works in a purposeful manner. Table III gives the number of flowers visited per minute.

Thus during favourable weather *Apis florea*, Fab., on an average, visits six flowers per minute.

Its *modus operandi* on flowers is ideal for cross-pollination. Alighting on a flower it sends its proboscis down immediately to a nectary and in consequence the head comes in contact with anthers and gets heavily dusted with pollen. The next nectary is reached with the body usually lying across the anthers. Much more frequently, however, the bee lies across the apex of the stigma to lap up nectar; it is this posture that results in pollination.

* The collections were made by Messrs. K. G. Bhandari, B. Singh, R. Takoo, N. Kishore, the late S. Datt, Sana Ullah and the author.

† 12th and 24th January, 1930.
27th February, 1930.
24th November, 1930.
7th and 10th February, 1931.

TABLE I

Showing meteorological data favourable for insect flight during toria *and* sarson *seasons in 1930 and 1931 respectively*

Month and year	Flowering period of	Dates	Collection made for		Mean maximum temperature (F)	Mean minimum temperature (F)	Mean humidity per cent	Amount of sun-shine		Amount of rain-fall (inches)	Wind velocity	
			Hrs.	Mts.				Hrs.	Mts.		Maximum Miles	Minimum per hour
November 1930	*toria*	19-25	15	..	77·85	48·28	66·71	50	30	..	2	1
December 1930	*toria*	1-7	13	..	78·14	45·28	60·71	44	30	..	2	1
January 1930	*sarson*	13-19	16	30	62·85	36·28	81·28	..	..	·7	3	1
February 1930	*sarson*	13-19	6	..	78·00	47·43	72·42	..	..	..	2	1
November 1931	*toria*	11-17	12	..	82·42	49·00	53·42	62	25	..	3	1
December 1931	*toria*	7-13	14	..	73·28	43·28	73·28	53	15	..	3	1
January 1931	*sarson*	24-30	12	30	66·28	38·14	72·00	47	48	..	3	1
February 1931	*sarson*	13-19	10	..	67·42	41·85	74·14	44	42	..	3	1

TABLE II

Showing numbers of Apis florea *Fab. collected from* toria *and* sarson *during 1930 and 1931*

Name	1930		1931	
	toria (November 19-25 December 1-7)	*sarson* (January 13-19 February 13-19)	*toria* (November 11-17 December 7-13)	*sarson* (January 24-30 February 13-19)
Apis florea Fab. . . .	62	188	216	370

TABLE III

Showing number of sarson *flowers visited per minute by* Apis florea *Fab.*

Date	Time of observation		Duration of observation (minutes)	Total number of flowers visited	Number of flowers visited in one minute
	From P.M.	To P.M.			
19-1-30	12·1	12·7	6	30	5
19-1-30	1·5	1·6	1	8	8
19-1-30	2·29	2·32	3	22	7·3
8-2-30	2·34	2·39	5	37	7·4
14-2-30	2·42	2·47	5	25	5
26-1-31	2·52	2·54	2	10	5
9-2-31	2·53	2·55	2	16	8
12-2-31	2·58	3·9	11	45	4
14-2-31	2·41	2·49	8	41	5·1

Fam. ANDRENIDÆ.—This family was strongly represented. Table IV gives the names and numbers of the members of this family collected from *toria* and *sarson* during the specified weeks.

It is seen from Table IV that *Andrena ilerda* Cam. and *Halictus* sp. are more abundant in *sarson* and *toria* crops than any other species of *Andrenidæ*. Both these solitary bees are exceedingly industrious and work in a purposeful manner. Because of these qualities and their numbers and body structure these bees are among the most important pollinators of flowers. Their *modus operandi* on flowers is identical with that of *Apis florea* Fab.

At Lyallpur *Andrena ilerda* Cam. begins to visit *toria* flowers in the second week of November. It reaches its maximum numbers in December : in fact it is during this month that it predominates over all other insect visitors. It constructs its nest in and around *toria* fields. For this purpose it makes a 22 in.—25 in. long tunnel with a number of side tunnels along its course.

In the case of an allied species each side of tunnel is said to terminate in a cell in which balls of ' bee-bread ' (for egg-laying) are stored.

TABLE IV

Showing names and numbers of Andrenidæ collected from toria *and* sarson *during 1930 and 1931*

Name	1930		1931	
	toria (November 19-25 December 1-7)	*sarson* (January 13-19 February 13-19)	*toria* (November 11-17 December 7-13)	*sarson* (January 24-30 February 13-19)
Andrena ilerda Cam.	299	25	384	23
Halictus sp.	22	51	112	46
A. lœna Cam.	8	3	..	10
A. satellita Nurse	..	3	..	17
Halictus salsettensis Ckll.	..	2	..	14
Andrena sp.	1	2	2	2
Andrena sp.	3	1	2	2
A. ephippium Spin. var. *dilecta* Mocs.	..	2	..	..
A. fulvicrus Kirby	..	..	..	2

Six observations were made to study the duration of a pollen-collecting trip. The method adopted was to keep a watch over the burrow from which an *Andrena ilerda* Cam. was seen coming out. (In all observations the burrow entrance was blocked with a clod which was removed when the insect returned).

It will be observed from Table V that the first visit of *Andrena ilerda* Cam. (apart from the first forced return in observation II) lasted for 3 to 4½ hours. The material collected during this trip required 7-10 minutes to be unloaded. The second visit lasted for about 1½ to 2½ hours, the insect taking 2-4 minutes to unload. The third visit was of the shortest duration for it lasted only from 19 minutes to 1½ hours. For pollination the first visit, and to a lesser degree the second visit, are most important, because ' an examination of the anthers of the freshly opened flowers at about 3 P.M. showed them to be absolutely devoid of pollen grains which are evidently carried away by their insect visitors ' [Ali Mohd. *et al*, 1931].

TABLE V

Showing numbers and duration of pollen-collecting trip of Andrena ilerda *Cam. during favourable weather*

No. of observation	Date	Time		Duration of						Remarks.
		Left burrow	Returned to burrow	First visit		Second visit		Third visit		
				hrs.	mts.	hrs.	mts.	hrs.	mts.	
I	29-11-1930	10·13 A.M.	1·23 P.M.	3	10	..	..	..	..	Observation discontinued after 3-35 P.M.
		1·31 P.M.	3·35 P.M.	..	..	2	4	..	..	
II	1-12-1930	10·36 A.M.	12·13 P.M.	1	37	..	..	..	..	Returned at 12·13 being hotly persued by *Philanthus depredator*. Took shelter under a lump of earth and on removal of clod ran into the burrow.
		12·19 P.M.	1·45 P.M.	..	..	1	26	..	..	
		1·48 P.M.	..	..	..	..	..	..	..	Did not return up to 5-30 P.M. when observation was discontinued.
III	2-12-1939	10·9 A.M.	1·14 P.M.	3	5	..	..	..	..	Did not come out upto 5-30 P.M. when observation was discontinued.
		1·24 P.M.	3·46 P.M.	..	..	2	22	..	..	Caught in a tube placed at the entrance next day.
		3·50 P.M.	5·11 P.M.	..	..	..	..	1	21	
IV	8-12-1930	2·10 P.M.	4·49 P.M.	..	..	2	39	..	..	Observation discontinued after 4·49 P.M.
V	20-12-1930	10·19 A.M.	2·46 P.M.	4	27	..	..	..	..	Observation discontinued after 5-30 P.M. as the insect did not return.
		2·55 P.M.	4·48 P.M.	..	..	1	53	..	..	
		4·50 P.M.	5·0 P.M.	..	..	..	..	0	10	
VI	22-12-1930	3·6 P.M.	4·47 P.M.	..	..	1	41	..	..	Observation discontinued after 4·47 P.M.

Like *Apis florea* Fab. *Andrena ilerda* Cam. also works in a purposeful manner and table VI gives the number of flowers visited in one minute.

TABLE VI

Showing number of flowers visited per minute by Andrena ilerda *Cam.*

Date	Time of observation		Duration of observation (minutes)	Total number of flowers visited	Number of flowers visited in one minute
	From P. M.	To P. M.			
26-11-30	1·28	1·30	2	13	6·5
26-11-30	2·46	2·49	3	18	6
28-11-30	1·34	1·36	2	15	7·5
4-12-30	12·15	12·19	4	33	8.2
16-12-30	1·30	1.33	3	26	8·6
19-12-30	2·40	2·42	2	16	8
27-11-31	3·6	3·11	5	39	7.8
30-11-31	1·15	1·17	2	15	7·5
5-12-31	1·15	1·18	3	22	7·3
14-12-31	12·45	12·49	4	32	8

Thus during favourable weather *Andrena ilerda* Cam., on an average, visits 7·5 flowers per minute.

A. ilerda Cam. is the most important insect for *toria* pollination, but being wild it is not possible to do anything with it in a practical way to ensure its presence, or augment its numbers, in *toria* fields.

At Lyallpur the appearance of *Halictus* sp. in *toria* synchronizes with its (*toria*) flowering : it remains active in this crop until *sarson* flowers appear. Thus before the appearance of *Andrena ilerda* Cam. it plays the most important part in the pollination of *toria*.

In its nesting habits it resembles *Andrena ilerda* Cam. It lives in small colonies, each member occupying a cell which is joined to the main tunnel by a side branch.

Table VII gives the number of flowers visited by *Halictus* in one minute.

TABLE VII

Showing number of flowers visited per minute by Halictus *sp.*

Date	Time of observation		Duration of observation (minutes)	Total number of flowers visited	Number of flowers visited in one minute
	From P. M.	To P. M.			
17-1-30	12·0	12·8	8	20	2·5
26-1-30	2·58	3·3	5	18	3·6
19-2-30	2·10	2·14	4	14	3·5
22-2-30	1·25	1·28	3	17	5·6
16-11-31	1·30	1·34	4	13	3·2
20-11-31	1·46	1·49	3	7	2·3
30-11-31	2·11	2·17	6	23	3·8
11-12-31	2·1	2·3	2	8	4

Thus during favourable weather *Halictus* sp., on an average, visits 3·5 flowers per minute.

Fam. COLLETIDÆ.—*Colletes reticulata* (Cam.), *C. nursei* Cam., and *Colletes* sp. are the only representatives of these primitive bees which were taken from *sarson* flowers. Only six specimens were collected and this fact alone marks them out to be useless as pollinating agents.

Fam. XYLOCOPIDÆ.—*Xylocopa* (*Nyctomelita*) *nasalis nasalis* Westw. is the only representative of this family secured from *toria* and *sarson* flowers. It is a powerful flier producing a loud buzzing noise during flight. It is never abundant—only eight specimens were collected—and this fact alone rules it out from the list of useful pollinators.

Fam. CERATINIDÆ.—*Ceratina sexmaculata* Sm. is a casual visitor to *toria* and *sarson* flowers. It is a slow and lazy worker and its method of obtaining nectar is such that only the front of its head comes in contact with the anthers. It has no value as a pollinating agent.

In Burma, as I have already said, I have not yet come across *Chilo simplex*. There the principal borer seems to be *Schœnobius bipunctifer*.

Damage to sugarcane.

A good deal has been said in this respect in the first paper. The work was continued on the same lines after that paper was written and also a visit was paid to several places in Bengal, the cane-breeding station at Coimbatore, to Hebbal Farm in Mysore, to Manjri Farm in Bombay and to Nagpur to get a general idea of borer pests in these places. The occurrence of the beetle pests in the Kamrup Farm also gave an opportunity of gauging the external agents of damage, especially the Dynastine beetles, at their real capability of damage. The results of the further experimental work at Pusa and observations at the places mentioned are summarized below :—

The incidence of attack on sugarcane by the insects dealt with in these papers is correlated with climatic conditions. Favourable climatic conditions, enabling the crop to grow rapidly, have a great effect in controlling the activities of the pests, the crop in such cases easily outgrowing their attack. But with unfavourable climatic conditions, especially drought and want of moisture in the soil (especially in places like Pusa and many places in Upper India where no irrigation is given to the crop), the insects get the upper hand, and owing to want of growth and tillering on the part of the plants, the loss caused by their attack is not compensated for, the result being that the percentage of attack becomes very high.

At Pusa the principal damage to sugarcane is caused in the early stages of its growth in April, May and June when the climatic conditions are characterized by high temperature, low humidity (see the chart given in the first paper opposite page 370) and absence or scantiness of rainfall. In April 1920 the damage to some of the thick canes at Pusa was as high as 10 per cent. whilst at Coimbatore and Hebbal in Mysore, similar canes exhibited hardly any damage. The canes at these places, although planted about the same time as these at Pusa, were far more advanced in growth than those at Pusa on account of the more favourable climatic conditions prevailing at these places. The canes at Manjri, planted earlier and grown under irrigation, were certainly not as good as the Coimbatore and Hebbal canes as regards growth and infestation by borers. This again is ascribable to the more unfavourable climatic conditions at Manjri than at Coimbatore and Hebbal.

The correlation of damage and climatic conditions holds good in all varieties of cane, thick as well as thin, but thin ones show a greater

Fam. NOMADIDÆ.—Of the three species collected *Nomada* 2 spp. are comparatively more abundant as is seen from the following table :—

TABLE VIII

Showing names and numbers of Nomadidæ collected from toria *and* sarson *during 1930 and 1931*

Name	1930		1931	
	toria (November 19-25 December 1-7)	*sarson* (January 13-19 February 13-19)	*toria* (November 11-17 December 7-13)	*sarson* (January 24-30 February 13-19)
Nomada 2 spp.	65	38	163	23
Crocisa ramosa Lep. ?	..	..	1	..

The general appearance of *Nomada* 2 spp. is suggestive of *Polistes hebræus* (Fab.)

During November and December, they were often seen at 8 A.M. suspended from leaves of *toria* by their mandibles. They are poor fliers and always fly low to the ground. They live as parasites in the nests of *Andrena* spp. and *Halictus* spp. for their larvæ are fed ' upon the provisions originally destined for the progeny of the host species ' [Imms, 1934]. They are, therefore, undesirable visitors to *toria* and *sarson* fields.

Fam. ANTHOPHORIDÆ.—*Anthophora vedetta* Nurse has the longest proboscis among the bees discussed in this paper. It prefers to feed in flowers where the nectaries are deep seated, e.g., ' *taramira* ' (*Eruca sativa*). It is, therefore, very rarely that one collects it from *sarson*.

Fam. BEMBECIDÆ.—*Bembex trepanda* Dahlb. is the only representative of this family taken from *toria* and *sarson* flowers.

It nests in the ground and shows parental care for its offspring. It preys upon Syrphidæ, Muscidæ and Calliphoridæ which it supplies daily to its larvæ. It is therefore an undesirable visitor to *toria* and *sarson* flowers.

Fam. LARIIDÆ.—*Liris hæmorrhoidalis* (Fab.) is the only representative of this family secured from *toria* flowers. It preys upon *Andrena ilerda* Cam. and other bees and is therefore an undesirable visitor to *toria* flowers.

Fam. PHILANTHIDÆ.—*Philanthus depredator* Smith is the only representative of this family secured from *toria* flowers.* Table IX gives the numbers of this insect collected from *toria* flowers during the specified weeks.

* It is in hibernation during the flowering period of *sarson*.

TABLE IX

Showing numbers of Philanthus depredator *Smith collected from* toria *during 1930 and 1931*

Name	1930	1931
	toria (November 19-25 December 1-7)	*toria* (November 11-17 December 7-13)
Philanthus depredator Smith	90	118

P. depredator Smith is a handsome and graceful insect. It constructs sinuous burrows in the soil. It closes the burrow entrance before going out to 'hunt'. This is done by shovelling back the soil particles with its legs 'in the manner of a dog digging'. On its return the prey is at first deposited on the ground near to the entrance hole which is then opened and the prey dragged into the burrow.

P. depredator Smith alternates its work of destruction with that of feeding on nectar. It is, however, a very slow and unsteady worker as is seen from Table X.

TABLE X

Showing number of flowers visited per minute by Philanthus depredator *Smith*

Date	Time of observation		Duration of observation (minutes)	Total number of flowers visited	Number of flowers visited in one minute
	From	To			
	P.M.	P.M.			
20-11-30	2·1	2·3	2	8	4
23-11-30	2·16	2·21	5	20	4
29-11-30	2·16	2·21	5	18	3·6
1-12-30	1·0	1·7	7	29	4·1
21-11-31	12·0	12·2	2	9	4·5
27-11-31	1·4	1·7	3	14	4·6
30-11-31	1·15	1·20	5	23	4·6

Thus, on an average, this insect visits about four flowers per minute.

Its main object in visiting *toria* flowers, however, is to prey upon *Andrena ilerda* Cam., and *Apis florea* (Fab.), etc. for provisioning its nest.

P. depredator Smith attacks a bee when it (bee) is busy collecting pollen and nectar, and on average takes 30 seconds (average of 12 observations) to paralyse it. Afterwards, it is 'carted' to the burrow in the usual Sphegid manner. Thus *P. depredator* Smith is the most unwelcome visitor to *toria* flowers.

Fam. VESPIDÆ.—Impregnated females of *Polistes hebræus* (Fab.) and *Vespa orientalis* * Linn. visit *toria* flowers during November and 1st week of December.

They are predaceous upon Apidæ and Andrenidæ: they feed upon their honey-stomachs which they obtain by biting off the thorax. They are thus undesirable visitors to *toria* flowers.

Fam. EUMENIDÆ.—Of the three species collected *Odynerus* sp. was comparatively more abundant as is seen from the following table:—

TABLE XI

Showing names and numbers of Eumenidæ collected from toria *and* sarson *during 1930 and 1931*

Name	1930		1931	
	toria (November 19-25 December 1-7)	*sarson* (January 13-19 February 13-19)	*toria* (November 11-17 December 7-13)	*sarson* (January 24-30 February 13-19)
Odynerus sp.	16	..	26	..
Eumenes dimidiatipennis Sauss.	..	..	2	..
Eumenes sp.	1	..	..	..

Odynerus sp. is a slenderly built insect. It visits *toria* flowers to feed on nectar and pollen. Because of its smooth body it is useless as a pollinating agent.

The female possesses a formidable sting. It is used to sting Lepidopterous larvæ into a state of torpor for storing them in a specially constructed earthen cell as food for its progeny.

Fam. SCOLIIDÆ.—*Campsomeris thoracicus* (Fab.), *C. thoracicus* var. *aureicollis* Lep. and *Scolia* sp. are the only representatives of this family secured from *toria* flowers. They are rapid fliers and are difficult to catch. During work they show a certain degree of persistency and fly rather than crawl,

* It is interesting to record here that on 22-11-31 at 3-14 P.M. a King crow (*Dicrurus macrocercus macrocercus* Vieill.) was observed to snap at and swallow three *Vespa orientalis* Linn. within five minutes.

from flower to flower. They obtain nectar like honey bees. But they are never abundant, therefore, their value as pollinating agents is limited.

Fam. CHRYSIDIDÆ.—Three specimens of *Chrysis indica* Macs. were collected from '*toria*' flowers. It has a brilliant metallic green colour and when disturbed it rolls itself quickly into a ball. It is a parasite of *Bembex*, *Odynerus* and *Eumenes*.

Fam. FORMICIDÆ.—Only two representatives, namely *Cataglyphis bicolor* subsp. *Setipes* (Forel), and *Messor barbarus* (Linn.) var. *instabilis* Sm. of this family were found visiting *toria* and *sarson* flowers to feed on nectar.

During feeding *C. bicolor* subsp. *Setipes* (Forel) introduces its head from between the floral 'claws' to reach the nectaries, the body sprawling over the adjacent flowers. When frightened it drops to the ground. Its body is smooth and unfit for the carriage of pollen.

Winged forms of *Messor barbarus* Linn. var. *instabilis* Sm. visit *toria* and *sarson* flowers but are never abundant. Their body being covered with hairs is very well suited for the carriage of pollen. Therefore, they cannot be entirely useless as pollinating agents.

Order DIPTERA

Fam. SYRPHIDÆ.—This family was strongly represented as is seen from the following table :—

TABLE XII

Showing names and numbers of Syrphidæ collected from toria *and* sarson *during 1930 and 1931*

Name	1930		1931	
	toria (November 19-25 December 1-7)	*sarson* (January 13-19 February 13-19)	*toria* (November 11-17 December 7-13)	*sarson* (January 24-30 February 13-19)
Eristalis tenax (Linn.)	28	66	19	74
E. quinquelineatus (Fab.)	10	13	18	8
E. æneus Scop.	8	7	11	2
E. tæniops Wied.	4	4	..	3
Sphærophoria indiana Big.	3	4	4	1
Syrphus balteatus (de Geer)	..	..	6	1
Lasiopticus albomaculatus Macq.	1	..	..	1
Ischiodon scutellaris (Fab.)	3	..	..	..

Eristalis tenax (Linn.) is a heavy bodied insect which bears a close resemblance to *Apis indica* Fab. During flight it produces a loud hum. It is a graceful insect to watch on the wing, but its movements on the flowers are awkward and clumsy. It is a spasmodic worker because 'hovering' over a flower and sitting and cleaning itself are as important to it as feeding.

Its *modus operandi* on a flower is identical with that of *Apis florea* Fab. described before. Its progress on flowers is very satisfactory as is seen from Table XIII.

TABLE XIII

Showing number of flowers visited per minute by Eristalis tenax *Linn.*

Date	Time of observation		Duration of observation (minutes)	Total number of flowers visited	Number of flowers visited per minute
	From	To			
	P.M.	P.M.			
18-1-30	3·5	3·12	7	47	6·7
25-1-30	2·7	2·10	3	18	6
7-2-30	1.38	1.49	11	97	8·8
19-11-30	12·10	12·18	8	49	6·1
	A.M.	A.M.			
8-12-30	11·4	11·8	4	39	9·7
	P.M.	P.M.			
13-12-30	1·58	2·1	3	26	8·6
11-2-30	1.15	1·18	3	15	5
	A.M.	A.M.			
11-11-31	10·9	10·15	6	35	5·8
24-11-31	11·11	11·20	9	60	6·6
	P.M.	P.M.			
7-12-31	1·5	1·10	5	34	6·8

Thus, on an average, it visits seven flowers per minute.

It is found in the fields from early morning to late afternoon and is met with in all types of weather. It is an important pollinator.

The other species of *Eristalis* though much less abundant are equally efficient as pollinating agents. *Sphærophoria indiana* Big. is a small sized insect which hovers 'poised motionless' in the air over a flower before alighting. It is a spasmodic worker.

Lasiopticus albomaculatus Macq., *Ischiodon scutellaris* Fab., and *Syrphus balteatus* de G. are of little significance as pollinating agents. The larvæ of the last named, however, destroy the Mustard Aphis.

Fam. AGROMYZIDÆ.—*Phytomyza atricornis* Meig., a representative of this family, is a minute insect which is quite abundant towards the end of *sarson* season. When disturbed it shoots up in the air and looks like a dust particle. It is found on the wing in the mornings, evenings and on cloudy days, but has never been observed visiting *sarson* flowers. When it is sunny and warm it takes shelter under cover of the leaves lying on the ground or other suitable shady places.

Its larvæ damage *sarson* leaves by making zigzag whitish galleries. When infestation is severe every leaf may be affected. The attacked leaf becomes distorted, turns yellow and ultimately falls down.

Fam. MUSCIDÆ.—Six species, namely, *Musca domestica nebulo vicina* Macq., *M. vitripennis* Meig., *M. domestica nebulo* Fab., together with three undetermined species of the genus *Musca* are the only representatives of this family secured from the flowers of the two crops.

Musca domestica nebulo vicina Macq. is an erratic and an unstable worker, and is not a persistent seeker of pollen and nectar. It also licks up stigmatic secretions. When feeding on nectar its body usually lies perpendicularly between the stalks of the stamens and the style of the stigma, but when licking up stigmatic secretions or feeding on pollen its body usually rests on petals. After every 'feed' it may settle on the body of the observer, on bags, bamboos, plants, or on the ground, or may even engage in a playful 'combat' with another 'fellow'. But it is found (along with other Muscids) in the fields from morning till late in the afternoon and is active both during fine and inclement weather. Therefore, it is safe to infer that Muscids in general and *Musca domestica nebulo vicina* Macq. in particular may play a minor part in pollination.

Fam. CALLIPHORIDÆ.—Of the six species of this family collected *Trichometallea pollinosa* Tns. was consistently more abundant as is seen from Table XIV.

TABLE XIV

Showing names and numbers of Calliphoridæ collected from toria *and* sarson *during 1930 and 1931*

Name	1930		1931	
	toria (November 19-25 December 1-7)	*sarson* (January 13-19 February 13-19)	*toria* (November 11-17 December 7-13)	*sarson* (January 24-30 February 13-19)
Trichometallea pollinosa Tns.	24	14	19	29
Rhinia discolor Fab.	4	3	29	6
Lucilia sericata Meig.	2	..	5	1
Calliphora erythrocephala Meig.	..	5	..	1
Sarcophaga sp.	..	..	5	..
Chrysomyia megacephala Fab.	1	..	..	..

Trichometallea pollinosa Tns. feeds on nectar and pollen as well as licks up stigmatic secretions. Its habits and mode of feeding resemble those of *Musca domestica nebulo vicina* Macq. When working seriously its rate of progress is fairly satisfactory (Table XV).

TABLE XV

Showing number of flowers visited per minute by Trichometallea pollinosa *Tns.*

Date	Time of observation		Duration of observation (minutes)	Total number of flowers visited	Number of flowers visited per minute
	From	To			
	A.M.	A.M.			
18-1-30	10·12	10·16	4	18	4·5
21-1-30	11·39	11·43	4	11	2·75
	P.M.	P.M.			
25-1-30	3.0	3·2	2	8	4
	A.M.	A.M.			
25-11-30	10.48	10·53	5	21	4·2
26-11-30	10·0	10·3	3	9	3
	P.M.	P.M.			
1-12-30	12·30	12·32	2	11	5·5
6-2-31	2.30	2·33	3	7	2·3
17-2-31	1·7	1·9	2	7	3·5
20-11-31	1·18	1·22	4	15	3·75
15-12-31	1·17	1·19	2	12	6

Thus it visits, on an average, 3·9 flowers per minute.

It is a fairly useful insect as a pollinating agent.

Rhinia discolor Fab. is about the size of a house-fly, but is darker in colour with whitish abdomen. It hovers over a flower like a Syrphid pinned to the spot: it may, however, dart to one side, disappear momentarily and then reappear about the same spot. During flight it produces a characteristic buzzing sound.

Its habits and mode of feeding resemble those of *T. pollinosa* Tns. Because of its numbers its value as a pollinating agent cannot be questioned.

L. sericata Meig., *C. erythrocephala* Meig., and *C. megacephala* Fab. are too few in *toria* and *sarson* flowers to be of any use as pollinating agents.

Fam. SEPSIDÆ.—Of the two species collected, *Sepsis* sp. was commoner as is seen from Table XVI.

TABLE XVI

Showing names and numbers of Sepsidæ collected from toria *and* sarson *flowers during 1930 and 1931*

Name	1930		1931	
	toria (November 19-25 December 1-7)	*sarson* (January 13-19 December 7-13)	*toria* (November 11-17 December 7-13)	*sarson* (January 24-30 February 13-19)
Sepsis sp.	..	98	3	66
S. sphippium Bezzi	..	7	..	2

Sepsis sp. is a slenderly built insect. After every 'feed' it may clean its smooth body for as long as nine minutes before visiting another flower. It is a sluggish and an erratic worker but because of its abundance its value as a pollinating agent cannot be doubted.

Fam. CONOPIDÆ.—*Conops erythrocephala* Fab. is the only representative of this family caught in November from *toria* flowers. Its larvæ are endoparasites of *Andrena* and *Vespa*. It is, therefore, an unwelcome visitor to *toria* flowers.

Fam. ORTALIDÆ.—*Chrysomyza demandata* Fab. is the only representative of this family secured from *toria* and *sarson* flowers. Because of its very small numbers, it is useless as a pollinating agent.

Fam. CORDYLURIDÆ.—Only two specimens of *Scatophaga* sp. were secured from *sarson* in 1930. It is useless as a pollinating agent.

Fam. TRYPETIDÆ.—*Dacus zonatus* Saund. is the representative of this family that was secured only once from *toria* flowers. It is useless as a pollinating agent.

Fam. EMPIDÆ.—*Hilara* sp. is the only representative of this family of predaceous flies collected from *sarson* which, becuase of its very rare occurrence, is useless as a pollinating agent.

Fam. MILICHIIDÆ.—*Desmometopa M-nigrum* Zett. is the only representative of this family which was collected only once. It is useless for pollination.

Order LEPIDOPTERA

Names and numbers of the Butterflies collected from *toria* are given below: they were never found visiting *sarson* flowers.

TABLE XVII

Showing names and numbers of Butterflies collected from toria during 1930 and 1931

Name	1930	1931
	toria (November *19-25* December 1-7)	*sarson* (November *11-17* December 7-13)
DANAIDÆ :		
Danaus chrysippus (Linn.)	6	11
NYMPHALIDÆ :		
1. *Precis orithya* Linn.	..	1
2. *Vanessa cardui* (Linn.)	1	2
3. *Hypolimnas misippus* Linn.	..	1
PIERIDÆ :		
1. *Catopsilia crocale* Cram.	5	7
2. *Anaphœis mesentina* Cram. = *aurota* Fab.	5	4
3. *Pieris brassicæ* Linn.	1	2
LYCÆNIDÆ :		
Polyommatus sp.	1	..
HESPERIIDÆ :		
Badamia exclamationis Fab.	1	1

The Butterflies mentioned in Table XVII above visit flowers for feeding on *nectar*.

To obtain nectar a Butterfly suspends itself from petals and simultaneously probes the nectaries with its extended proboscis. To reach the next flowers it may either 'flutter' across the entire bunch of flowers or may fly to it. On an average a Butterfly may visit one flower in one minute.

Because of their hairy bodies and presence both during fine and inclement weather the value of Butterflies as pollinating agents cannot be doubted.

Fam. PYRALIDÆ.—*Noctuelia floralis* Hubn. is the only representative of this family secured from *toria* and *sarson* flowers. It is nocturnal and whether it visits these flowers in sufficiently large numbers at night to play any part in their pollination yet remains to be ascertained.

Fam. ARCTIIDÆ.—*Utetheisa pulchella* Linn. was about as common as *D. chrysippus* Linn. During feeding it crawls over the flowers rather sluggishly ; as such its value as a pollinating agent cannot be doubted.

Fam. NOCTUIDÆ.—*Earias insulana* (Bosid.) and *Laphygma exigua* Hub. are the only representatives of this family secured from *toria* and *sarson* flowers respectively. They were evidently accidental visitors.

A single caterpillar of *Plusia chalcytes* Fab. was found damaging *toria* flowers in December, 1930.

Fam. LYMANTRIIDÆ.—*Euproctis* sp. was secured from *toria* flowers only once.

Order COLEOPTERA

Fam. CARABIDÆ.—One specimen of *Pterostichus leus* Andr.—a representative of this family of nocturnal and predaceous beetles—was secured in November.

Fam. NITIDULIDÆ.—*Hoptoncus lutelus* Chevr. is the only member of this family of which two specimens were collected from *toria* and *sarson* flowers.

Fam. COCCINELLIDÆ.—Four species namely, *Chilomenes sexmaculata* Fab., *Coccinella septempunctata* (Linn.), *C. undecimpunctata* Linn. and *Adonia variegata* subsp. *doubledayi* Muls. of this family were secured from *toria* and *sarson* flowers. They usually abound in *toria*.

Larvae and adults of these predaceous beetles move about actively among *toria* and *sarson* flowers in search of their prey, e.g., Aphididae. The larvae are exclusively carnivorous, but the adults alternate their insect food with nectar. Therefore the greatest good they do is to destroy the injurious Mustard Aphis (*Siphocoryne indobrassicae* Das). Also, because of their body structure and assiduity with which they search out their prey, their value in the transfer of certain amount of pollen cannot be doubted.

Fam. DERMESTIDÆ.—*Attagenus bifasciatus* Oe. is the only representative of this family which has been secured from *toria* flowers.

It feeds on nectar and as many as five of them may be found in the same flower. During feeding its body lies parallel to the style with its head directed towards the nectaries. It may remain in this position for as long as 12 minutes.

It visits *toria* flowers in January when the crop is ready to be harvested. This fact coupled with its sedentary habits marks it out to be useless as a pollinating agent.

Fam. MELYRIDÆ (*Malachiidæ*).—A single specimen of *Laius malleifer* Champ.—a representative of this family—was collected in November.

Fam. TENEBRIONIDÆ.—A single specimen of *Opatroides vicinis* Fairm.—a representative of this family—was collected in January.

Fam. CHRYSOMELIDÆ.—About six specimens of the dreaded *Aulacophora foveicollis* Luccap. were collected from November to February. This insect

immunity and also a greater resistance to drought. This will be apparent from a reference to the figures published in the Imperial Entomologist's Annual Report for 1920, pp. 73-74. We find therefore that particular varieties are suited to particular areas according to differences in local climatic conditions. As a rule thick ones do not fare so well in Upper and Western India as thin ones. Different varieties of cane show different degrees of pest resisting qualities though no variety has yet been found to resist pests wholly.

The presence or absence of alternative foodplants in the locality is observed to exercise a great influence on the occurrence of at least some of the borers in sugarcane. The remarks in this respect on *Diatræa venosata*, *Scirpophaga xanthogastrella* and the Noctuid borer C. S. 1666 may be seen.

The attempts at dealing with the borer pests of sugarcane and external agents of damage which work with effects similar to those produced by the borers must take into consideration the following points :—

(1) The suitability or otherwise of the cane itself to the climatic conditions of the place where it is grown.

(2) The habits of the cane, especially its capacity for tillering during the early stages of its growth, as varieties which tiller well show much greater immunity than those in which tillering is poor.

(3) The drought-resisting quality of the cane, especially in places where no irrigation is practised.

(4) The natural immunity of the cane against pests and diseases and

(5) the effect of the presence or absence of alternative foodplants of the different borers.

The borer problem is not so acute at Coimbatore and other places in Southern India with favourable climatic conditions as in Northern India where in many places, such as Pusa, thick canes yield about 50 per cent. less than they are capable of yielding. As described in the first paper, only one out of every four shoots which grow of such canes comes to be harvested, the other three being killed. Therefore the problem for such areas seems to be to evolve a variety of sugarcane which can be planted at the time of the breaking of the monsoon or even after, but which will ripen at the time when canes do now-a-days. This can probably be done by selection of the tillers which grow late but ripen along with the mother canes.

If this be possible the borer question can be solved to a very great extent for localities with adverse climatic conditions such as Upper India.

winters over as an adult and therefore the specimens which were collected had evidently come out to 'enjoy' the sunshine.

Fam. CURCULIONIDÆ.—Two specimens of *Myllocerus maculosus* Desb. were collected in December. Like *Aulacophora* this insect also winters over as an adult.

Order NEUROPTERA

Fam. CHRYSOPIDÆ.—*Chrysopa* sp. is the only representative of this family which has been collected from the two crops. Though useless as a pollinating agent, its larva does good work in destroying the Mustard Aphis, each larva killing 25-28 Aphids per day.

Order ORTHOPTERA

Fam. MANTIDÆ.—*Creobroter gemmatus* Stoll. is the only representative of this family secured from flowers. It preys upon insect visitors to *toria* and *sarson* flowers and is, therefore, an undesirable creature.

Order ODONATA

Fam. LIBELLULIDÆ.—*Pantala flavescens* Linn.—a representative of this family—was occasionally seen settled on *toria* and *sarson* plants. Its visits were purely for the purpose of preying upon insects making up the fauna of the two crops but what pracisely they preyed upon could not be ascertained.

Order THYSANOPTERA

Fam. AEOLOTHRIPIDÆ.—(?) *Aeolopthrips* sp. is the only representative of this family collected from *toria* and *sarson* flowers. It feeds both on nectar and sap of flowers : it obtains the latter substance by lacerating the flower tissue with its rasping-sucking mouth-parts.

Order RHYNCHOTA

Fam. PENTATOMIDÆ.—The Painted Bug, *Bagrada picta* (Fab.), is a serious pest of *Brassicae*. It is fairly common in *toria* in November where it is seen settled on flower-buds sucking sap with its stylets. Seriously attacked flower-buds open badly and imperfectly.

Dolycoris indicus Stal. and *Nezara viridula* (Linn.) were less abundant and of absolutely no value as pollinating agents.

Fam. COREIDÆ.—One specimen of *Liorhyssus hyalinus* Fab. collected in February from *sarson* was evidently an accidental visitor and as such useless as a pollinating agent.

Fam. LYGAEIDÆ.—One specimen each of *Spilostethus pandurus* (Scop.), *Graptostethus servus* (Fab.) and *Oxycarenus laetus* Kirby was collected in December, January and February respectively. Because of their small numbers Lygaeids are of no importance in pollination.

Fam. PYRRHOCORIDÆ.—The Red Cotton Bug, *Dysdercus cingulatus* (Fab.), is very rarely met with in *toria* and *sarson* and is, therefore, useless as a pollinating agent.

Fam. MEMBRACIDÆ.—The common Tree Hopper, (?) *Leptocentrus* sp- which abounds on ' Sirin ' (*Albizzia lebbek*) was collected only once in November.

Fam. FULGORIDÆ.—The sugarcane Leaf Hopper, *Pyrilla perpusilla* (Walk.), is a pest of sugarcane and wheat : the two specimens collected in November were evidently accidental visitors.

Fam. APHIDIDÆ.—The common Mustard Aphis, *Siphocoryne indobrassicae* Das. (=*pseudobrassicae* Davis) abounds on *toria* and *sarson*. It congregates in enormous numbers on the stalk of the inflorescence, flower-buds and flowers from which it sucks vital fluids with its stylets. The attacked stalk gnarls badly and the flowers open poorly, while the pods formed from such flowers are misshapen and usually do not develop any seed. It is, therefore, a serious pest whose absence rather than presence is to be desired.

RELATIVE SIGNIFICANCE OF THE IMPORTANT POLLINATORS

A method of study.—It will be observed from the foregoing pages that the insect visitors of *toria* and *sarson* flowers constitute a complex phenomenon of organic activity. Some are sap-feeders, e.g., *Bagrada picta* (Fab.) *Siphocoryne indobrassicae* Das. (=*pseudobrassicae* Davis.), etc., some are predaceous upon other insects, e.g., *Creobroter gemmetus* Stoll., *Liris haemorrhoidalis* (Fab.), *Philanthus depredator* Smith, etc., a few are parasites of other insects, e.g. *Nomada* sp., a few are accidental visitors to these crops, e.g. *Dysdercus cingulatus* (Fab.), *Pyrilla perpusilla* Walk., etc., whilst a vast majority (particularly Hymenoptera and Diptera) visit these flowers for pollen and nectar.

To study the relative significance of the insect visitors to *toria* and *sarson* flowers as pollinating agents the following method was adopted :—

Two healthy shoots of the same age were selected on an easily accessible plant and their opened and about to open flowers were nipped off with scissors. One of these shoots was used for cross-pollination by insects and the other as control. The flower-buds were carefully examined for Thrips and other small insects. Each branch was then enclosed in a muslin bag (30 in. by 15 in.) big enough to provide ample space for its growth. The top of the bag was fastened to an inverted L shaped bamboo stick hammered in the ground. The bags thus secured are able to stand a casual storm which may occur during the growing season of *toria* or *sarson*. Six insects were introduced daily between 12 noon to 2 P.M. into each bag. These insects were captured in glass tubes and immediately put into the bags from the upper end. At the close of each experiment all the unopened flowers enclosed in a bag were nipped off and the bag tied up in the usual manner so as to allow the seeds to mature. In due course the plants were harvested and the seeds formed in each pod were counted. The results are presented in Table XVIII. (Only a typical example is given in each case).

It will be observed from Table XVIII that the largest number of normal seeds per pod was found in bags with *Andrena ilerda* Cam. and *Apis florea* Fab., while the lowest number of seeds was formed in bags with *Sepsis* sp. and *Trichometallea pollinosa* Tns.

It will also be observed from Table XVIII that the average number of normal seeds formed per pod in the case of the experimental plants was

TABLE XVIII

Showing relative significance of the insect pollinators a : *bag with insects.* b : *Control.* c : *free flowering*

	Andrena ilerda Cam.			*Apis florea* F.			*Halictus* sp.			*Philanthus Repredator* Smith			*Eristalis* sp.			*Sepsis* sp.			*T. pollinosa* Tns.		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Total flowers .	118	111	73	215	303	50	68	66	53	108	170	85	176	124	30	26	21	14	220	166	55
Pods formed .	115	22	73	202	45	50	58	34	51	40	16	78	139	51	28	5	4	13	102	53	54
Per cent pod setting	97·46	19·82	100·0	93·98	14·85	100·0	85·99	51·51	96·26	37·0	9·4	91·8	78·98	41·13	93·33	19·2	19·0	92·8	46·4	31·9	98·2
Average No. of normal seed per pod	7·53	1·42	18·51	6·95	1·54	18·62	3·68	1·88	20·02	1·1	0·8	12·2	4·38	2·07	28·32	1·2	0·8	10·7	1·6	1·7	17·2

TABLE XIX

Showing the total number of insects collected during November-March, 1930 and 1931.

	1930				1931			
	toria		*sarson*		*toria*		*sarson*	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
HYMENOPTERA—								
Andrena ilerda	586	43·73	76	5·35	1420	39·78	40	3·46
Apis florea	221	16·49	690	48·62	684	19·16	602	52·07
Philanthus depredator	90	6·71	..	..	118	3·30	..	..
Halictus sp.	52	3·88	89	6·27	367	10·28	46	3·98
Nomada spp.	65	4·85	38	2·67	163	4·56	23	1·98
Other Hymenoptera	98	7·31	60	4·22	183	5·12	126	10·89
DIPTERA—								
Eristalis spp.	50	3·73	90	6·34	48	1·34	87	7·52
Trichometallea pollinosa	64	4·77	74	5·21	62	1·73	58	5·01
Sepsis sp.	..	..	211	14·86	16	·44	69	5·96
Musca sp.	..	..	5	·35	35	·98	2	·17
Rhinia discolor	4	·29	3	·21	135	3·78	6	·51
Other Diptera	49	3·65	58	4·08	146	4·09	75	6·48
LEPIDOPTERA	10	·74	16	1·12	66	1·84	8	·68
COLEOPTERA	23	1·71	4	·28	60	1·68	9	·77
RHYNCHOTA	31	2·31	..	..	48	1·34	4	·34
NEUROPTERA	1	·07	..	..	15	·42	1	·08
THYSANOPTERA	..	..	8	·56	..	..	..	..
ORTHOPTERA	..	..	..	..	3	·08	..	
Total	1344	..	1422	..	3569	..	1156	..
GRAND TOTAL	7491	..	..	..	..	..	..	..

Publications of the Imperial Department of Agriculture in India.

To be had from :—

The Office of the Agricultural Adviser to the Government of India, Pusa, Bihar, and from the following Agents :—

(1) Thacker, Spink & Co., Calcutta.
(2) W. Newman & Co., Calcutta.
(3) Rai M. C. Sarkar Bahadur & Sons, Calcutta.
(4) Higginbothams, Ltd., Madras.
(5) Thompson & Co., Madras.
(6) D. B. Taraporevala, Sons & Co., Bombay.
(7) Thacker & Co., Ltd., Bombay.
(8) Sunder Pandurang, Bombay.
(9) Rai Sahib M. Gulab Singh & Sons, Lahore
(10) Manager, Educational Book Depôt, Nagpur.

A complete list of the publications of the Imperial Department of Agriculture in India can be obtained on application from the Agricultural Adviser to the Government of India, Pusa, Bihar, or from any of the above-mentioned Agents.

These publications are :—

1. The *Agricultural Journal of India*. A Journal dealing with subjects connected with agricultural economies, field and garden crops, economic plants and fruits, soils, manures, methods of cultivation, irrigation, climatic conditions, insect pests, fungus diseases, co-operative credit, agricultural cattle, farm implements, and other agricultural matters in India. Illustrations, including coloured plates, form a prominent feature of the Journal. It is edited by the Agricultural Adviser to the Government of India, and is issued once every two months or six times a year. *Annual Subscription*, Rs. 6 or 9*s*. 6*d*., including postage. Single copy, R. 1-8 or 2*s*.
2. Scientific Reports of the Agricultural Research Institute, Pusa.
3. Annual Review of Agricultural Operations in India.
4. Proceedings of the Board of Agriculture in India.
5. Proceedings of Sectional Meetings of the Board of Agriculture.
6. Memoirs of the Imperial Department of Agriculture in India :
   (*a*) Botanical Series.
   (*b*) Chemical Series.
   (*c*) Entomological Series.
   (*d*) Bacteriological Series.
   (*e*) Veterinary Series.
7. Bulletins issued by the Agricultural Research Institute, Pusa.
8. Indigo Publications.
9. Books.

The following are the publications of the last two years :—

Scientific Reports of the Agricultural Research Institute and College, Pusa (including the Report of the Secretary, Sugar Bureau), for the year 1919-20. Price, R. 1.

Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert and the Secretary, Sugar Bureau), for the year 1920-21. Price, R. 1-8.

Review of Agricultural Operations in India, 1919-20. Price, R. 1-4.

Review of Agricultural Operations in India, 1920-21. Price, R. 1-4.

Proceedings of the Board of Agriculture in India, held at Pusa on the 13th February, 1922, and following days (with Appendices). Price, R. 1.

Proceedings of the Third Meeting of Mycological Workers in India, held at Pusa on the 7th February, 1921, and following days. Price, As. 11.

Proceedings of the Second Meeting of Agricultural Chemists and Bacteriologists, held at Pusa on the 7th February, 1921, and following days. Price, As. 10.

Proceedings of the Fourth Entomological Meeting, held at Pusa in February 1921. Price, Rs. 7-8.

MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA

Botanical Series

Vol. X, No. VI. "Kumpta" Cotton and its Improvement, by G. L. KOTTUR, B.Ag. Price, R. 1-12 or 3*s*.

Vol. XI, No. I. Some Aspects of the Indigo Industry in Bihar. Part I. The Wilt Disease of Indigo. Part II. The factors underlying the seed production and growth of Java Indigo, by ALBERT HOWARD, C.I.E., M.A., and GABRIELLE L. C. HOWARD, M.A., with the assistance of CHOWDHARY RAMDHAN SINGH and MAULVI ABDUR RAHMAN KHAN. Price, R. 1-2 or 2*s*.

Vol. XI, No. II. Studies in Diseases of the Jute Plant. (1) *Diplodia Corchori*, Syd., by F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S. Price, Rs. 2 or 2*s*. 8*d*.

Vol. XI, No. III. Morphology and Parasitism of *Acrothecium Penniseti* n. sp. (A New Disease of *Pennisetum typhoideum*), by MANORANJAN MITRA, M.Sc. Price, R. 1-4.

Vol. XI, No. IV. Studies in Gujarat Cottons, Part I, by MAGANLAL L. PATEL, B.Ag. Price, Rs. 2 or 2*s*. 6*d*

Vol. XI, No. V. Die-back of Chillies (*Capsicum* spp.) in Bihar, by JEHANGIR FARDUNJI DASTUR, M.Sc. Price, R. 1 or 1*s*. 4*d*.

Vol. XI, No. VI. The Influence of Atmospheric Conditions upon the Germination of Indian Barley, by W. YOUNGMAN, B.Sc. Price, As. 9 or 1*s*.

Vol. XI, No. VII. Correlation of Colour Characters in Rice, by G. P. HECTOR, M.A., B.Sc. Price, R. 1-4 or 1*s* 8*d*.

Vol. XI, No. VIII. The Inheritance of Characters in Rice, II, by F. R. PARNELL, M.A., Ag. DIP. (Cantab.), with the assistance of G. N. RANGASWAMI AYYANGAR, B.A., K. RAMIAH, L.Ag., and C. R. SRINIVASA AYYANGAR, L.Ag. (*In the press.*)

Chemical Series

Vol. V, Nos. VII & VIII. The Gases of Swamp Rice Soils, V—A Methane-oxidizing Bacterium from Rice Soils, by P. A. SUBRAHMANYA AYYAR, B.A., and The Gases of Swamp Rice Soils, VI—Carbon Dioxide and Hydrogen in relation to Rice Soils, by W. H. HARRISON, D.Sc. Price, As. 12 or 1*s*. 3*d*.

Vol. V, No. IX. The Retention of Soluble Phosphates in Calcareous and Non-calcareous Soils, by W. H. HARRISON, D.Sc., and SURENDRA LAL DAS, M.Sc. Price, R. 1 or 1*s*. 4*d*.

Vol. V, No. X. Windrowing Sugarcane in the North-West Frontier Province. Part I. The Effect on the Economical and Agricultural Situation, by W. ROBERTSON BROWN. Part II. The Effect on the Composition of Sugarcane, by W. H. HARRISON, D.Sc., and P. B. SANYAL, M.Sc. Price, As. 12 or 1*s*.

Vol. VI, No. I. Investigations on Indian Opium No. 1. Non-environmental Factors influencing the Alkaloidal Content and Yield of Latex from the Opium Poppy (*Papaver somniferum*), by HAROLD E. ANNETT, D.Sc. (Lond.), F.I.C., M.S.E.A.C., HARI DAS SEN, M.Sc., and HAR DAYAL SINGH, B.Sc. Price, R. 1-8 or 2*s*.

Vol. VI, No. II. Investigations on Indian Opium No. 2. The Effect of Non-environmental Factors on the Alkaloidal Content and Yield of Latex from the Opium Poppy (*Papaver somniferum*) and the bearing of the work on the functions of Alkaloids in Plant Life, by HAROLD E. ANNETT, D.Sc. (Lond.), F.I.C., M.S.E.A.C. Price, R. 2 or 2*s*. 9*d*.

Vol. VI, No. III. Studies in Soil Moisture, Part I, by B. H. WILSDON, B.A. (Oxon.), I.E.S. Price, R. 1-8 or 2*s*.

Vol. VI, Nos. IV & V. Variations in some Characteristics of the Fat of Buffalo and Cow Milk with changes in Season and Feeding; The Mutual Applicability of the Analytical Figures for Butter Fat and Ghee, by F. J. PLYMEN, A.C.G.I., and A. R. PADMANABHA AIYER, B.A. Price, As. 12 or 1*s*. 3*d*.

Entomological Series

Vol VI, Nos. I—IX. Life-histories of Indian Insects : Microlepidoptera, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.C.S. F.Z.S. Price, Rs. 7-8 or 11*s.* 3*d.*

Vol. VII, Nos. I & II. New Indian Gall Midges (Diptera), by E. P. FELT ; and Description of a Rhinocyphine larva from Shillong, by MAJOR F. C. FRASER, I.M.S. Price, As. 12.

Vol VII, No. III. Indian Grass Gall Midges, by E. P. FELT. Price, As. 10 or 1*s.*

Vol. VII, Nos. IV&V New Indian Gall Midges (*Itonididæ*), by E. P. FELT ; Three New Wasps from India, by G. R. Dutt, B.A. Price, As. 12 or 1*s.*

Vol. VII, No. VI. Life-histories of Indian Insects. Diptera : *Sphryracephala Hearseiana*, Westw., by S. K. SEN, B.Sc. Price, As. 12 or 1*s.*

Vol. VII, Nos. VII. & VIII. New and Rare Indian Odonata in the Pusa Collection; Further Notes on *Rhinocypha* Larvæ, by Major F. C. FRASER, I.M.S. Price, R. 1-4 or 1*s.* 9*d.*

Bacteriological Series

Vol. I, No. VIII. Pebrine in India, by C. M. HUTCHINSON, C.I.E., B.A. Price, Rs. 3-8 or 5*s.* 6*d.*

Vol. I, No. IX. Studies on the Root Nodule Organism of the Leguminous Plants, by N. V. JOSHI, M.Sc., B.A., L.Ag. Price, R. 1-4 or 2*s.* 6*d.*

Veterinary Series

Vol. III, No. II. The Virulence of Tubercle Bacilli isolated from Bovine Lesions in India, by A. L. SHEATHER, B.Sc., M.R.C.V.S. Price, R. 1-4 or 1*s.* 8*d.*

Vol. III, No. III. Bovine Lymphangitis, by A. L. SHEATHER, B.Sc., M.R.C.V.S. Price, R. 1-8 or 2*s.*

Vol. III, No. IV. Studies in Rinderpest, by W. A. POOL, M.R.C.V.S., and T. M. DOYLE, F.R.C.V.S. (*In the press.*)

Vol. III, No. V. Etiology of Equine Contagious Abortion in India by T. M. DOYLE, F.R.C.V.S. (*In the press.*)

BULLETINS ISSUED BY THE AGRICULTURAL RESEARCH INSTITUTE, PUSA

No. 96. A Summary of Experiments on Rice in Bihar and Orissa from 1912 to 1919, by G. C. SHERRARD, B.A. Price, As. 10.

No. 97. *Ustilago Crameri*, Koern. on *Setaria italica*, by S. SUNDERARAMAN, M.A. Price, As. 4.

No. 98. The Course that Surra runs in Camels when Naturally Contracted and when Artificially Inoculated, by H. E. CROSS, M.R.C.V.S., D.V.H., A.Sc. Price, As. 5.

No. 99. The Course that Camel Surra runs in Ponies, Buffaloes and other Animals, by H. E. CROSS, M.R.C.V.S., D.V.H., A Sc. Price, As. 4.

No. 100. Annotated List of Indian Crop-Pests, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S. Price, R. 1-8.

No 101. Some Insects recently noted as Injurious in South India, by T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S. Price, As. 8.

No. 102. Borers in Sugarcane, Rice, etc., by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. GHOSH, B.A. Price, R. 1.

No. 103. Some Indian Economic Aleyrodidæ, by C. S. MISRA, B.A. Price, As. 8.

No 104. The Rice Leaf-hoppers, by C. S. MISRA, B.A. Price, As. 6.

No. 105. Cotton Bollworms in India, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. S. MISRA, B.A. Price, As. 8.

No. 106 The Pink Bollworm in Egypt, by LEWIS H. GOUGH, Ph.D., F.E.S. Price, R. 1.

No. 107 Experiments in Egypt on the Survival of the Pink Bollworms (resting stage larvæ) in Ripe Damaged Cotton Bolls buried at different depths, by F. C. WILLCOCKS. Price, As. 5.

No. 108. Some Pests of Cotton in North Bihar, by C. S. MISRA, B.A. Price As. 6.

No. 109. *Tukra* Disease of Mulberry, by C. S. MISRA, B.A. Price, As. 4.

No. 110. The Preservation of Wood against Termites, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. GHOSH, B.A. Price, As. 3.

No. 111. Stored Grain Pests, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. GHOSH, B.A. Price, As. 14.

BULLETINS ISSUED BY THE AGRICULTURAL RESEARCH INSTITUTE, PUSA—(*Concld.*)

No. 112. Notes on Rearing Insects in Hot Climates, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. GHOSH, B.A. Price, As. 7

No. 113. Hints on Collecting and Preserving Insects, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S. Price, As. 10.

No. 114. The Preparation and Reproduction of Scientific Illustrations, by A. W. SLATER. Price, As. 4.

No. 115. Note on Plant Imports into India, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S. Price, As. 7.

No. 116. A Survey of the Indian Poppy-growing Districts for Morphine Content of the Opium produced, by H. E. ANNETT, D.SC. (Lond.), F.I.C., M.S.E.A.C., HARI DAS SEN, M.SC., and HAR DAYAL SINGH, B.SC. Price, As. 2.

No. 117. Experiments with Castor Seed Conducted at Sabour, C. SOMERS-TAYLOR, B.A. (Price, As. 3.)

No. 118. The Saving of Irrigation Water in Wheat Growing, by ALBERT HOWARD, C.I.E., M.A., and GABRIELLE L. C. HOWARD, M.A. Price, As. 4.

No. 119. The Agricultural Development of Baluchistan, by ALBERT HOWARD, C.I.E., M.A., and GABRIELLE L. C. HOWARD, M.A. Price, As. 6.

No. 120. The Serum Simultaneous Method of Inoculation against Rinderpest, by W. A. POOL, M.R.C.V.S. Price, As. 2.

No. 121. Notes on Contagious Abortion in Pony and Donkey Mares, by R. BRANFORD, M.R.C.V.S., and T. M. DOYLE, F.R.C.V.S. Price, As. 5.

No. 122. Pusa 12 and Pusa 4 in the Central Circle of the United Provinces, by B. C. BURT, M.B.E., B.SC., F.C.S., ALBERT HOWARD, C.I.E., M.A., and GABRIELLE L. C. HOWARD, M.A. Price, As. 11.

No. 123. The Bundelkhand Cottons. Experiments in their Improvement by Pure Line Selection, by B. C. BURT, M.B.E., B.SC., F.C.S., and NIZAMUDDIN HAIDER. Price, As. 4.

No. 124. Safflower Oil, by ALBERT HOWARD, C.I.E., M.A., and J. STEWART REMINGTON. Price, As. 4.

No. 125. The Weevil Fauna of South India with special reference to species of Economic Importance, by T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S. Price, R. 1-4.

No. 126. Cawnpore-American Cotton, II. Further Field Trials (1918-20), Spinning Trials and Market Organization, by B. C. BURT, M.B.E., B.SC.F.C.S. Price, As. 4.

No. 127. The Coconut Bleeding Disease, by S. SUNDERARAMAN, M.A. Price, As. 8.

No. 128. *Helminthosporium* Disease of Rice, by S. SUNDERARAMAN, M.A. Price, As. 9.

No. 129. The Preparation of Anti-rinderpest Serum using Animals of moderate susceptibility as Virus Producers, by W. A. POOL, M.R.C.V.S., and T. M. DOYLE, F.R.C.V.S. Price, As. 12.

No. 130. Feeding Experiments at Government Cattle Farm, Hissar, by R. BRANFORD, M.R.C.V.S. and E. SEWELL, M.C., M.R.C.V.S. Price, As. 3.

No. 131. An Entomologist's Crop Pest Calendar for the Madras Presidency, by T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S. Price, As. 2.

No. 132. Report of Campaign against *Spodoptera mauritia*, Boisd. (*Noctuidæ*) in Malabar, by E. BALLARD, B.A., F.E.S. Price, As. 2.

No. 133. Results of Investigation of Bionomics of *Platyedra gossypiella*, Saunders, in South India, together with some notes on *Earias insulana* and *E. fabia*, by E. BALLARD, B.A., F.E.S. Price, As. 5.

No. 134. Supplementary Observations on Borers in Sugarcane, Rice, etc., by C. C. GHOSH, B.A. Price, As. 6.

No. 135. Some Observations on the Control of Field Rats in the Punjab, by M. A. HUSSAIN, M.A., and HEM SINGH PRUTHI, M.SC. Price, A. 1.

No. 136. The Hydrogen Ion Concentrations of some Indian Soils and Plant Juices, by W. R. G. ATKINS, O.B.E., SC.D., F.I.C. Price, As. 4.

SUMMARY

The insect visitors to *toria* and *sarson* flowers were collected for 131 days during November to February in 1930 and 1931, at Lyallpur. This collection includes 105 different species representing 55 families of 9 Orders of the Class Insecta. The habits and usefulness of these insects are discussed and it has been found that *Apis florea* Fab., *Andrena ilerda* Cam., *Halictus* sp. and *Eristalis tenax* Linn. are the most important pollinators.

A study of the hourly frequency of the insect visitors also confirms this conclusion.

Philanthus depredator Smith.—An insect predaceous upon bees—(in its relation to Indian bees) is brought to light for the first time. Its habits and capacity for destruction of bees are described.

ACKNOWLEDGEMENTS

I am greatly indebted to Khan Bahadur M. Afzal Husain for his suggesting the problem and for his guidance during the progress of the work. I am also much indebted to Ch. Ali Mohd. for his providing facilities for the work and to Ch. Mohd. Afzal for supplying me with the metereological data given in Table I. I wish to thank my colleagues, particularly Mr K. G. Bhandari, who helped mein this investigation by collecting insects. Thanks are also due to the authorities of the British Museum, London, for determining 70 per cent of the insects listed, the remaining 30 per cent having been determined by myself.

REFERENCES

Afzal Husain, M. (1930). *Rept. Dept. Agric. Punjab*, Pt. II, **1**, 159
Alderman, W. H. (1918). *Proc. Amer. Soc. Hort. Sci.*, **14**, 94-101
Ali Mohd., R. D. Singh and Z. Alam (1931). *Ind. J. Agric. Sci.* **1**, 109-36
Ali Mohd. (1935). *Ibid*, **5**, 1-30
Auchter, E. C. (1922). *Proc. Amer. Soc. Hort. Sci.*, **18**, 51-80
Burkill, I. H. (1906) *J. and Proc. Asiatic Soc., Bengal*, **2**, 511-25
Burkill, I. H. (1907). *Ibid.* **3**, 517-26
Burkill, I. H. (1908). *Ibid.* **4**, 179-231
Burkill, I. H. (1909). *Ind. Ins. Life* **1**, 222-3
Burkill, I. H. (1911). *J. and Proc. Asiatic Soc., Bengal*, **6**, 101-7
Farrar, C. L. (1931). *J. Eco. Ento.* **24**, 622-7
Ghosh, C. C. (1915). *Imp. Inst. Agric. Res. Pusa Bull.* **46** (second edition)
Imms, A. D. (1934). *A general text book of Entomology, London*
Treherne, R. C. (1923). *15th Ann. Rept. Quebec Soc. Prot. Plant*, 47-59
Waite, M. B. (1895). *Div. Veg. Path. U. S. Dept. Agric. Bull.*
Waite, M. B. (1899). *U. S. Dept. Agric. Year Book*, 167-80
Williams, R. D. (1925). *Welsh Plant Breeding Sta. Bull.* **4**, Ser. H.

GIPD 3 S—1000 IC of AR—24-8-40—90.

To check its inroads into uninfested localities seed cane free from *Chilo trypetes* Bisset should only be imported.

ACKNOWLEDGEMENT

This work was undertaken at the suggestion of Khan Bahadur M. Afzal Husain, Entomologist to Government, Punjab, Lyallpur (appointed Vice-Chancellor of the University of the Punjab in October 1938) to whom we are grateful both for suggesting the problem and for help and advice during the progress of this investigation.

SUMMARY

Chilo trypetes Bisset (Pyralidae : Lepidoptera) is a new pest of sugarcane which was discovered for the first time in the Punjab in 1923 by M. Afzal Husain, Entomologist to Government, Punjab, Lyallpur. It has a restricted distribution and has so far been recorded from Sialkot, Gurdaspur, Batala, Pathankot and Mukerian (Hoshiarpur). It feeds only on sugarcane and shows special preference for *barani* (rain-fed) crop.

Different stages of the pest are described and figured.

The pest is active from June-July to October when it completes its life-cycle in sixty-three to eighty-eight days. The moths of the second generation appear about September when they lay eggs and these give rise to caterpillars, which remain in sugarcane stubbles from November to June.

It begins to take toll of the crop when the plants are fairly grown up and the internodes are well-formed. Damage by this pest ranges from 15 to 20 per cent during normal years, but in years of serious attack it may be as high as 50 per cent. The leaves of the attacked cane dry up and the plant fails to grow; it breaks off easily when shaken by wind or a passing animal.

The pest can be controlled effectively by ploughing up the sugarcane stubbles any time from November to June. The uprooted stubbles should be collected and destroyed. In July the damaged canes should be removed and destroyed to kill the larvae.

REFERENCE

Bisset, G. A. (1933). *Proc. Roy. Ent. Soc.* (*London*) (B) **8**, 3

Rahman, Khan A. (1940). *Pb. Agric. Coll. Mag.* (*Lyallpur*) **7**; 19

GIPD—3 S—132 IC ot AR—4-12-40—86.

THE IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH

The Bionomics, Life-history and Control of the Grasshopper, *Poecilocerus pictus* (Fab.)— A new Pest of Cultivated Crops in North India

BY

HEM SINGH PRUTHI

AND

L. N. NIGAM

Reprinted from

The Indian Journal of Agricultural Science

Vol. IX, Part IV, August, 1939

PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI.
PRINTED BY THE MANAGER, GOVERNMENT OF INDIA PRESS, NEW DELHI,
1939.

THE BIONOMICS, LIFE-HISTORY AND CONTROL OF THE GRASSHOPPER *POECILOCERUS PICTUS* (FAB.)—A NEW PEST OF CULTIVATED CROPS IN NORTH INDIA

BY

HEM SINGH PRUTHI, M.Sc., Ph.D., F.N.I.

Imperial Entomologist

AND

L. N. NIGAM, B.Sc.

Assistant to Imperial Entomologist, New Delhi

(Received for publication on 10th February 1939)

(With Plates XXIX and XXX)

CONTENTS

		Pages
I.	Introduction	629
II.	Distribution	630
III.	Food plants and nature of damage	630
IV.	Life-history and description of immature stages :—	631
	Copulation	631
	Oviposition	631
	Egg	633
	Different nymphal stages	634
V.	Control measures	639
VI.	Summary	641
VII.	References	641

I. Introduction

The grasshopper *Poecilocerus pictus* (Fab.) is quite familiar to the students of entomology and needs no special introduction. On account of its large size it is selected as a type for teaching insect morphology in some Agricultural Colleges. Though its anatomy has been studied in some detail, its bionomics, life-history, etc., have not been fully investigated. Obviously this is due to the fact that this grasshopper has not attracted the attention of economic entomologists since it is not considered to be a pest of any cultivated crop. It chiefly feeds on a wild plant called *ak* (Hindustani), a species of the genus *Calotropis*, and hence it is popularly called as the *ak* grasshopper. With

the exception of a record by Fletcher [1914] of this grasshopper having been found damaging young fig trees in South India, it was not known to cause damage to any plants of economic value until recently when in the summer of 1937 the writers noticed it causing considerable damage to brinjal, castor and tomato in a village garden at Shadipur near the estate of the Imperial Agricultural Research Institute. During April and May it was observed feeding on *ak*, but when it had almost exhausted this food plant it migrated to the neighbouring crops named above. It was thus realized that this grasshopper threatened to be a potential pest of cultivated crops and therefore it was considered advisable to study its biology, range of food plants, etc., and try some methods of control. The grasshopper has been closely studied during the past two years and the results of the investigations are reported in the following pages.

II. Distribution

This grasshopper is known to occur throughout the plains of India except in Bihar, Bengal and Assam. Outside India it is found in Africa. It appears that this grasshopper likes dry and hot climate.

III. Food plants and nature of damage

Poecilocerus pictus, as its popular name (*ak* grasshopper) indicates, is very fond of *ak* and feeds upon every part of it, *e.g.*, leaves, stems, pods, flowers, etc., often reducing the plants to naked stems, not even leaving the green bark behind. With a view to investigating the potentiality of this grasshopper as a pest of cultivated crops, experiments were carried out with numerous food plants available at Delhi during summer, when this insect is commonly met with in the field. In order to know whether the hoppers were capable of growing and developing on different food plants, they were confined in tall wire gauze cages with different kinds of leaves which were changed every morning. The following plants were tried :—brinjal, tomato, *bhindi* (*Hibiscus esculentus*), potato, gourds, cabbage, radish, musk-melon, castor, oleander, maize, cotton, broad bean, hollyhock, sorghum, cowpea, *pipal* (*Ficus religiosa*), tobacco and sugarcane.

Out of the plants named above, the hoppers fed readily on the leaves and fruits of brinjal and tomato, and on the leaves of *bhindi*, potato, gourds, cabbage, radish, musk-melons, castor, oleander and maize. They underwent normal moulting and became adults. The hoppers fed moderately on cotton, broad bean, hollyhock, sorghum and cowpea, and underwent moulting. The *pipal* leaves were only nibbled a little and sugarcane and tobacco leaves were not eaten at all.

In the field so long as *ak* plants were available, the grasshopper was mostly confined to them. Where brinjal plants were growing in the vicinity of *ak*, the hoppers were found infesting them but to a less extent. It appears that this insect becomes a menace to cultivated crops if its population becomes very large during spring when it is still on its wild food plant, *viz.*, *ak*.

IV. Life-history and description of immature stages

The life-history of *P. pictus* in broad outline is as follows :—

The eggs are laid in soil from June to August and sometimes even in September. The winter is generally passed in the egg stage and the young hoppers hatch out towards the end of March or beginning of April at Delhi. The nymphs feed and grow during April and May and become adults about the end of the latter month, after undergoing five or six moults. The males and females start copulating within one or two weeks of the final moult, and egg-laying and active breeding continues up to the end of September, by which time the last batch of eggs has been laid. After the middle of October hoppers begin to dwindle in numbers, but there are numerous egg masses in the soil during winter. Only a very insignificant percentage of the eggs laid in summer hatch in autumn but the great majority do not hatch till the ensuing spring, as stated above.

The life-history is described in detail below :—

The two sexes can be easily distinguished. The males are smaller and more slender than the females. The extremity of the abdomen in the male is conical and turned upwards, while in the female it ends in a number of paired chitinous hooks, which constitute the ovipositor.

Copulation

The male does not start copulating immediately after it becomes adult. The pre-copulation period in this sex varies from five to eight days. However, the female is ready for copulation soon after it undergoes the final moult. On several occasions fresh adult females were given to sexually mature males and the copulation started almost immediately. The process of copulation is almost the same as in other grasshoppers. It may last from two to four, sometimes even six hours and in rare cases even one day. The males as well as females were found to copulate several times, which may be as many as fifteen times within twenty to twenty-five days, and both polyandry and polygamy are quite common. There is frequent copulation both before and after oviposition.

Oviposition

The egg-laying begins from twenty to twenty six days after the emergence of the female as adult. The period intervening between the first copulation and the first egg-laying varies from fourteen to twenty days.

The ovaries of females of different ages were dissected to note the time of maturity of eggs. It was found that in the case of the females which had copulated, the eggs were mature after fifteen or sixteen days, while in the ovaries of the virgin females the eggs were found to be fully mature after twenty two to twenty four days. The pre-oviposition period in the virgin females was found to be twenty four to twenty seven days. Observations on the pre-oviposition periods and the number of ovipositions and eggs laid within a period of two months of adult life have been summarized in Table I.

TABLE I

Pre-oviposition period and number of ovipositions and number of eggs laid

Serial No.	Date of attaining adult stage	Date of first oviposition	Pre-oviposition period (days)	Date of subsequent oviposition	No. of egg masses laid	No. of eggs
1	11th June 1938	3rd July 1938	23	21st July 1938	2	Kept in soil to note hatching
2	13th ,,	5th ,,	23	22nd ,,	2	
3	14th ,,	18th ,, (found after some time).	35	...	1	120
4	15th ,,	4th ,,	20	...	1	40 (on the surface)
5	14th ,,	5th ,,	22	12th July 1938	2	...
6	14th ,,	5th ,,	22	...	1	110
7	12th ,,	...	...	18th July 1938	2	...
8	14th ,,	5th July 1938	22	...	1+1	108
9	14th ,,	5th ,,	22	12th July 1938	2	...
10	17th ,,	8th ,,	22	24th ,,	1+1	108
11	16th ,,	5th ,,	20	...	1	77
12	16th ,,	7th ,,	22	...	1	...
13	18th ,,	14th ,,	27	...	1	...
14	19th ,,	13th ,,	25	...	1	...
15	19th ,,	14th ,,	26	...	1	...
16	19th ,,	21st ,,	33	...	1	...
17	15th ,,	6th ,,	22	...	1	...
18	15th ,,	8th ,,	24	...	1	133
	15th ,,	9th ,,	25	...	1	120
20	17th ,,	6th ,,	20—21	...	1	117
21	17th ,,	8th ,,	22	...	1	105
22	16th ,,	7th Nov. 1938	22	...	1	...
23	16th ,,	5th July 1938	20	...	1	65
24	17th ,,	6th ,,	20	22nd July 1938	2	105
25	17th ,,	17th ,,	31	...	1	98 (on wood)
26	15th ,,	8th ,,	24	26th July 1938	2	...
27	14th ,,	5th ,,	22	21st ,,	2	...
28	11th ,,	4th ,,	24	13th ,,	3	...
				28th ,,	...	...
		Average	23	...	1·4	116
			Virgin females.			
1	17th June 1938	12th July 1938	26	...	1	3 r 4
2	17th ,,	10th ,,	24	13th July 1938	2	...
3	17th ,,	11th ,,	25	...	1	102
4	29th ,,	22nd ,,	24	...	1	...
5	19th ,,	17th ,,	29	...	1	...
6	17th ,,	...	...	...	1	140
		Average	25 days	...	...	...

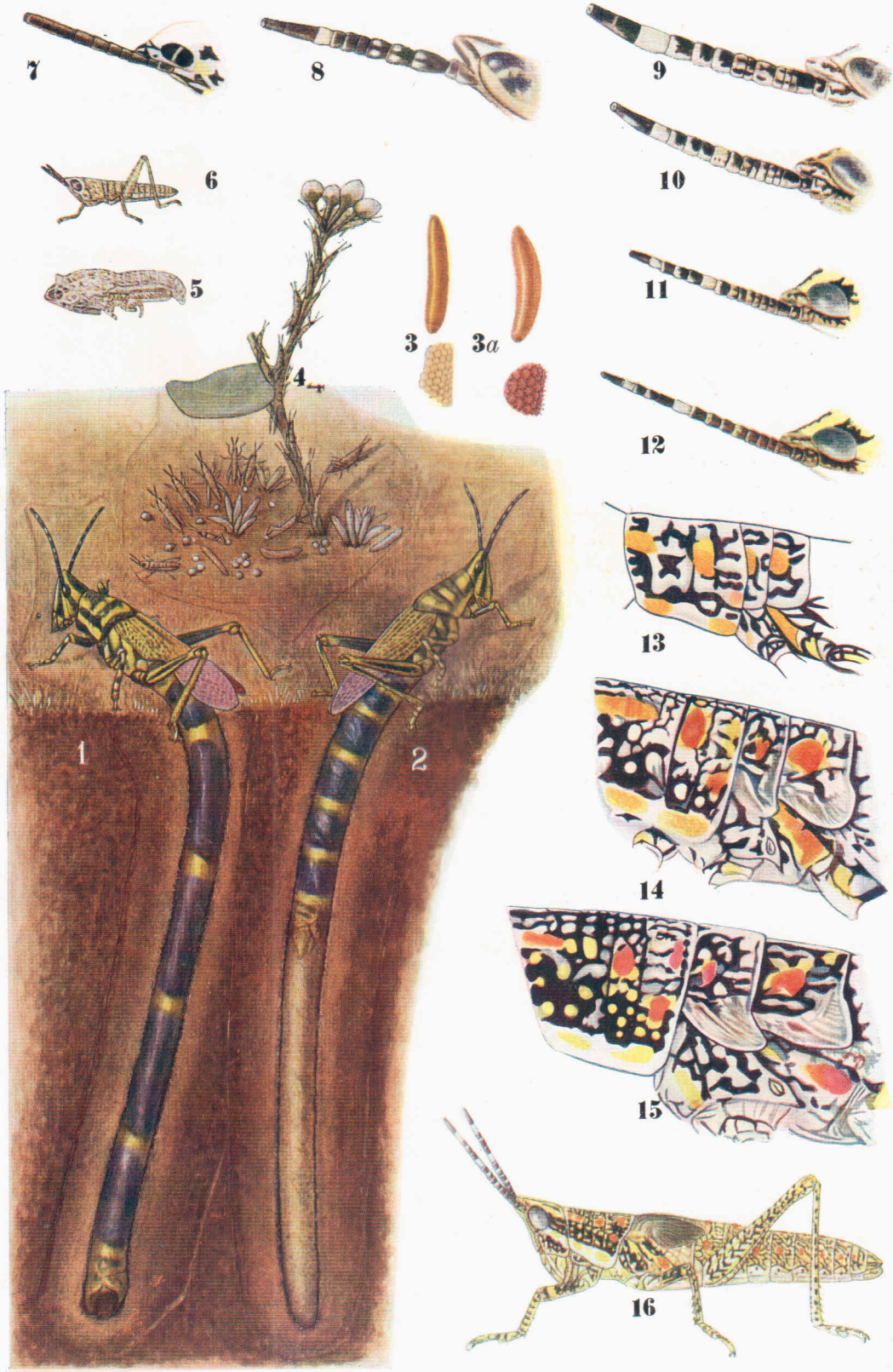

7
8
9
10
6
5
3
3a
11
4
12
13
1
2
14
15
16

PLATE XXIX

FIGS. 1 & 2. *Poecilocerus pictus*, females, in the process of egg laying. Note that the abdomen has been extended upto the length of about 5 in. (Fig. 1). In Fig. 2. the abdomen is being retracted after eggs have been laid, ($\times\frac{1}{2}$)

FIG. 3. Freshly laid egg ($\times 2\frac{1}{2}$), with a part of the chorion highly magnified

FIG. 3*a*. The egg about to hatch ($\times 2\frac{1}{2}$), with a part of the chorion highly magnified

FIG. 4. Freshly hatched young hoppers. Natural size

FIG. 5. Young 'larva' ($\times 2\frac{1}{2}$)

FIG. 6. 1st instar nymph ($\times 2\frac{1}{2}$)

FIGS. 7—12. Antenna and compound eye of the I—VI instar nymphs

I	$\times 10$
II—III	$\times 8$
IV	$\times 5$
V—VI	$\times 3$

FIG. 13. Lateral view of thorax of the 1st instar nymph ($\times 10$)

FIG. 14. Lateral view of thorax of the 3rd instar nymph ($\times 8$)

FIG. 15. Lateral view of thorax of the 5th instar nymph ($\times 5$)

FIG. 16. Sixth instar nymph ($\times 1\frac{1}{2}$)

The eggs are laid in the soil about 5-6 in. below the surface. Generally the soil which is selected for this purpose is of loose texture, hence more easily penetrable. The gravid females have inflated abdomens. When ready for egg-laying, the female trails its abdomen on the ground searching for a suitable spot by scratching the surface of the soil with its ovipositor. When such a spot has been found it starts making an egg chamber with the help of the anterior and dorsal valves of the ovipositor. The valves act like the prongs of a forceps. The egg-laying process has been studied in the laboratory in a large glass cage (1-5 ft. × 1 ft. × 1 ft.) which was half filled with soil. The top of the soil was covered with a thick card board leaving the soil uncovered near the sides only. The female was thus forced to bore holes in close proximity to the glass sides and thus the whole process could be easily watched. During the course of boring, the extremity of the abdomen rotates through an angle of 180°, pressing and making compact all sides of the burrow. The formation of the egg chamber takes from one to two hours. The chambers are generally 6-6½ in. deep. Though the abdomen is only 1·4 in. long in the normal position, it can be extended to reach the depth of chamber with the help of the elastic intersegmental membranes (Plate XXIX, fig. 1). In many cases the female makes several chambers and discards them without laying any eggs therein probably because of the unsuitable texture or moisture content of the soil. Sometimes the female turns its abdomen in a zigzag fashion if it meets with any obstacle inside the egg chamber. Before the eggs are actually laid the female exudes a fluid which is worked up into a frothy mass by the quick motions of the ovipositor valves and is deposited at the bottom of the egg chamber about 2 in. thick on which the eggs are laid one by one in a spiral manner so as to form a compact mass (Plate XXIX, fig. 2). The female gradually retracts its abdomen as the chamber gets filled up with eggs. When all the eggs have been laid, the vacant space in the chamber is filled with froth up to the top. The whole process takes about two to six and a half hours.

The female looks somewhat sluggish for a short time after oviposition. Generally one or two and sometimes three egg masses were laid by a single female during its life time under laboratory conditions. The unfertilized females generally laid one egg mass only. The number of eggs in a mass varied between 60 and 140, the average being about 116. It is likely that more than two egg masses are laid in nature.

Egg

The egg (Plate XXIX, fig. 3) is elongated, curved, almost cylindrical, thick in the middle and tapering towards the ends, which are bluntly rounded. When freshly laid, the egg is yellow but soon turns brown. The micropyle is darker in colour and can be easily demarked. When mature, the egg grows in thickness (Plate XXIX, fig. 3 *a*). There are two egg coverings, the chorion and the vitelline membrane. The former is sculptured and in a mature egg can be peeled off easily by scratching. The vitelline membrane is yellow, smooth but tough and cannot be pierced when pressed with an ordinary needle. When the egg is about to hatch, the young one inside can be seen through the

egg skin, moving its abdomen and striped hind femora. Just prior to hatching some black spots make their appearance on the surface of the chorion near the operculum. From these spots some transparent liquid oozes out, and it is at these spots that the membranes rupture and the 'vermiform larva' hatches out. Its head and antennæ (Plate XXIX, fig. 5) are bent downwards and the legs are folded. These "larvæ" make their way up through the dry froth by wriggling motions of their bodies and emerge out of the burrow in large numbers and present a very interesting appearance (Plate XXIX, fig. 4). The emergence of all the 'larvæ' from a single egg mass takes about ten minutes. Soon after reaching the surface of the soil, the 'larvæ' start the process of casting their covers, known as the intermediate moult. Just before this moulting, the cervical ampulla gets inflated and presents a two-knobbed swelling. By the alternate swelling and contraction of this ampulla the thin white skin is ruptured dorsally in the thoracic region and eventually the young nymph crawls out. The process of the intermediate moulting is completed within two to four minutes. Some previous authors have not considered this moult to be true one, but we, like Uvarov [1928], do not find any important difference between this and the subsequent moults.

The newly emerged nymphs are negatively geotropic, always trying to move upwards and ascending on any piece of stick or twig. They move in a mass towards the source of light and sit in clusters on any standing twig with their heads pointing upward (Plate XXIX, fig. 4). The nymphs begin to feed about twenty four hours after their emergence.

There are usually six nymphal moults before the individual reaches the adult stage. Sometimes there are five moults only. The duration of the various instars is variable. On an average (200 observations) they are as follows during summer :—

1st instar	9·7 days.
2nd „	7·8 „
3rd „	7·8 „
4th „	8·5 „
5th „	9·9 „
6th „	11·6 „

The total nymphal life lasts for fifty to fifty-six days during summer. In the case of those few eggs which hatch in autumn, the nymphal period is very long. Only a few of these nymphs become adults in November while the great majority of them over-winter and become adults in the following April after a nymphal life lasting seven or eight months.

Different Nymphal stages

First stage nymph.—The freshly emerged nymphs (Plate XXIX, fig. 6) are orange coloured, with white and faint blackish stripes. After the lapse of one day the blackish patterns become dark and the hoppers look yellowish grey in general appearance. They measure 9-12 mm. in length and about 2·5 mm. in breadth (in the region of the thorax). The pronotum is about 1·8 mm. long and the antenna about 2·25 mm.

THE IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH

Chilo trypetes Bisset (Pyralidae), a New Pest of Sugarcane from the Punjab

BY

KHAN A. RAHMAN

AND

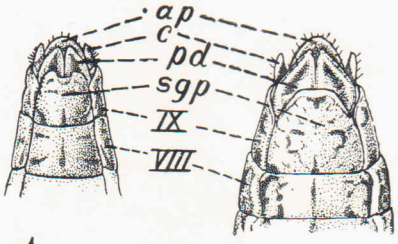
D. N. TANDON

Reprinted from

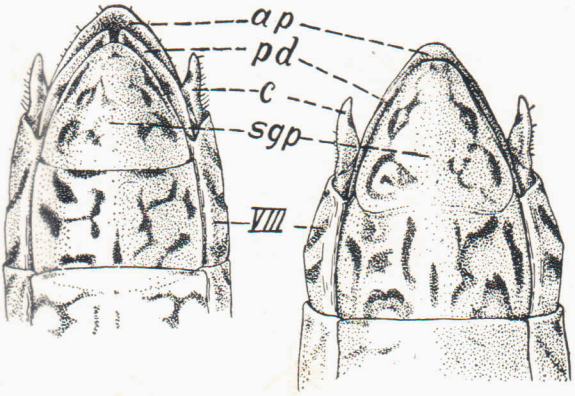
The Indian Journal of Agricultural Science

Vol. X, Part V, October 1940

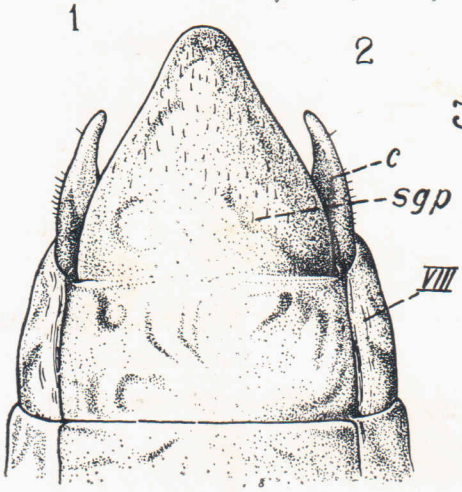
PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI.
PRINTED BY THE MANAGER, GOVERNMENT OF INDIA PRESS, NEW DELHI,
1940.



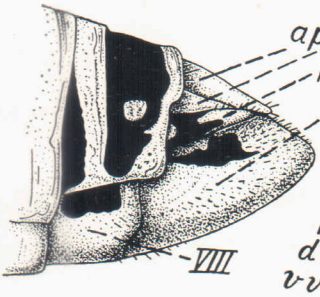
1 2



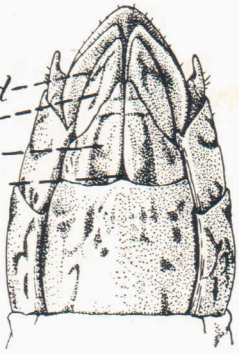
3 4



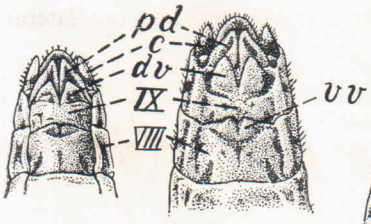
5



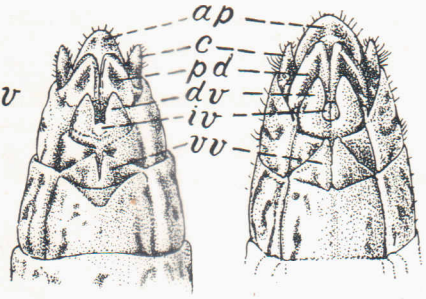
6



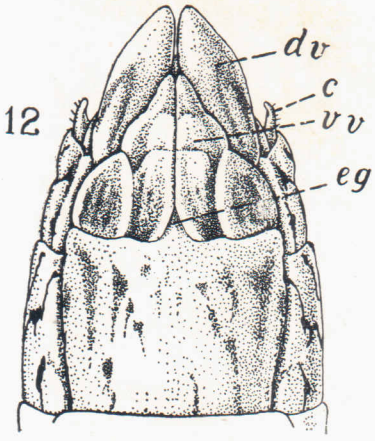
11



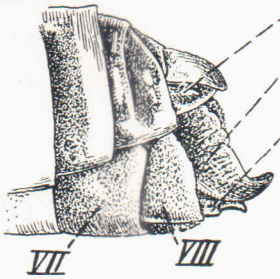
7 8



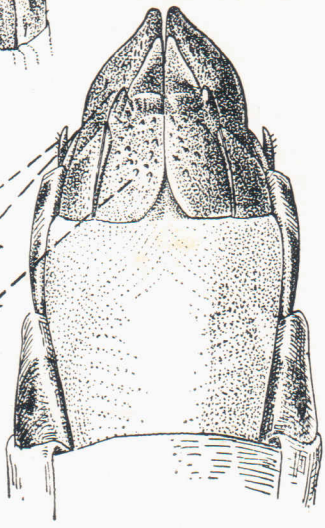
9 10



12



13



14

20-Mar-14 12:24 PM

PLATE XXX

FIG. 1—4 Posterior abdominal segments of the male nymphs of 1st, 3rd, 5th, and 6th instars respectively ; ventral view ; ×10

FIG. 5 Posterior abdominal segments of the male adult grasshopper ; ventral view ; ×10

FIG. 6 The same in lateral view ; ×7

FIGS. 7—12 Posterior abdominal segments of the female nymphs of 1st to 6th instars respectively ; ventral view ; ×10

FIGS. 13—14 Posterior abdominal segments of the adult female grasshopper ; lateral and ventral views respectively ; ×7

LEGEND TO LETTERING

ap—anal plate ; *c*—cerci ; *dv*—dorsal valves of the evipositor ; *eg*—egg guide ; *iv*—inner valves of the ovipositor ; *pd*—podical plates ; *sgp*—subgenital plate of the male ; *vv*—ventral valves of the ovipositor ; VII-VIII—seventh and eighth abdominal segments.

The head is conical and sloping in the front view. It projects forward between the compound eyes and forms a triangular area known as the fastigium. The margins of the fastigium are slightly raised. The eyes are oval, black and devoid of any stripe. The frons is traversed by a deeply sulcate frontal ridge, running from the tip of the fastigium up to the clypeus. The margins of the ridge—the frontal carina—are whitish in colour, and are bordered on each side by two yellow or orange patches.

The antennæ (Plate XXIX, fig. 7) are deep purple and are invariably eightsegmented. The first or the basal joint is cylindrical and the second is small and globular. The third to seventh segments are almost subequal. The eighth segment is very long and is equal in length to the three preceding segments taken together.

The pronotum is saddle shaped and has a very feeble medial carina. There are five yellow patches on each lateral lobe, the arrangement of which is constant as shown in the figure (Plate XXIX, fig. 13). The prosternum bears a very acute compressed aciculate tubercle, which is situated between the two coxæ. The mesonotum is a small narrow sclerite partly hidden below the pronotum. The metanotum resembles mesonotum except that it is broader than the latter. The metapleuræ have each a long oblique orange patch, in front of which are the small, almost circular spiracles (*sp.*) which are externally provided with two-lobed valves. The first pair of spiracles remain hidden under the pronotum.

The first and second pair of legs are small and have black and white markings all over. The third pair is stout. The upper and lower ridges of the hind femora are traversed with eight to nine and five to six black dots respectively. The hind tarsi are three-jointed, the terminal joint being provided with a pair of claws and a median pad, the arolium.

The abdomen is almost cylindrical. It has a mid-dorsal stripe of white spots interrupted with black markings. On each side of this stripe there is a lateral interrupted stripe of orange spots. Ventrally the abdomen is silver grey, with black lines interspersed all over. In both sexes ten terga are distinct, the last two being partially fused. The eleventh tergum and the supra-anal plate are fused into one piece at the sides of which and slightly lower in level are the two small cerci, the appendages of the eleventh abdominal segment. The number of apparent sterna in the two sexes are different. In the male there are ten sterna including the first one which is fused with the sternum of the metathorax. The ninth sternum is large, slightly depressed ventrally and deeply notched at the posterior margin ; this is the rudiment of the subgenital plate (Plate XXX, fig. 1, *sgp*). Above this plate there is a pair of triangular outgrowths known as the podical plates (*pd*). In the female also ten sterna are visible, the ninth being cleft into two triangular pieces, which are the rudiments of the dorsal valves of the ovipositor (Plate XXX, fig. 6, *dv*). Lying above the pieces there is a pair of triangular podical plates (*pd*) as in the male. At the posterior margin of the eighth sternum there is a very tiny pair of protruberances which are the rudiments of the ventral valves of the ovipositor (*vv*)

It is not easy to distinguish sexes at this stage as the rudimentary subgenital plate of the male which is notched at the posterior margin, and the ninth sternum of the female which is cleft into two parts, looks very much alike. But the presence of the rudimentary ventral valves of the ovipositor, present at the posterior margin of the eighth sternum, distinguishes the female from the male (Plate XXX, *cf.* figs. 1 and 7).

Second stage nymph.—The second stage nymph resembles in general appearance and colour the first stage nymph, but is bigger in size, measuring 10-13·5 mm. in length and 2·5 mm. across the pronotum. The antennæ are 3·0 mm. long and are usually nine-jointed (Plate XXIX, fig. 8), the sixth joint of the first stage having divided into two. Sometimes the antennæ consist of eight segments only. On the distal margin of the third to sixth joints there are two small white spots which are totally absent in the first stage. The dark compound eyes develop each a transverse whitish stripe.

There is no indication of the wing pads in this stage but the posterior angles of the meso and meta-nota become somewhat extended outwards getting thinner and slightly dark in colour.

There is no change in the abdomen except in the appearance of some new yellow patches, the broadening of the black patterns, and the further development of the external genitalia.

The ninth sternum or the subgenital plate of the male grows in size and the notch begins to flatten out. In the females the ventral valves and dorsal valves of the ovipositor grow longer and gradually extend backwards and cover part of the ninth segment and anterior half of the podical plates respectively (Plate XXX, fig. 8).

In this stage spiracles are visible on the lateral folds of the first eight abdominal segments, the first pair of spiracle being near the tympanum.

Third stage nymph.—The general colour of the body becomes deeper in this stage. The median yellow spots on the dorsal side of the abdomen turn orange in colour. The length of the body is 15-17 mm.

The antennæ (Plate XXIX, fig. 9) in this stage are about 4 mm. long and are ten or eleven jointed, the fifth joint and sometimes sixth as well of the previous stage having each been divided into two segments. The tenth or the last segment is dull purple in the basal half and light purple in the distal region, and can therefore be mistaken for two joints.

The pronotum measures 2·7 mm. The meso and meta-nota develop distinct, thin triangular outgrowths at their postero-lateral angles. These outgrowths are the rudiments of the future wings (Plate XXIX, fig. 14, *wp.*).

The subgenital plate of the male completely loses its notched appearance and becomes rounded at the posterior margin (Plate XXX, fig. 2). In the female the eighth segment develops a crescent shaped fold (*eg*) directed inwards near the bases of the ventral valves which now cover the base of the dorsal valves. This fold is the rudiment of the egg guide which becomes distinct in the fifth stage. A small transverse pad-like growth (*iv*) appears in this stage also between the bases of the dorsal valves (Plate XXX, fig. 9).

Fourth stage nymph.—The general colouration becomes still deeper in this stage. The body measures 20-24 mm. long and 3-4 mm. broad. The eyes are light brown near the lateral carina of the front, and their transverse stripes become broader than in the previous instar. There are twelve to fourteen joints in the antennæ which are now 5·6 mm. long (Plate XXIX, fig. 10). The third and fourth segments show an incomplete division, while the fifth segment of the previous instar has divided into two segments.

The pronotum measures 3·2 mm. in length. The postero-lateral angles of the meso-notum and meta-notum grow thin and dark and acquire oblique folds and thus form the rudiments of wing pads (Plate XXIX, fig. 15). Further, in some nymphs towards the end of this stage the wing pads begin to turn upwards, and the mesonotal pair comes to lie below the metanotal pair. However, in great majority of the nymphs the wing pads turn in the fifth stage.

In the male, the subgenital plate becomes conical and spatula-like in appearance. The podical plates get gradually pushed up and become compressed due to the development of the subgenital plate. In the female (Plate XXX, fig. 10) the ventral valves extend further backwards and their posterior ends become narrow and pointed. The dorsal valves also grow bigger, the transverse pad at their base develops a longitudinal fissure resulting in two minute appendages (*iv*), which are the rudiments of the inner pair of valves of the ovipositor.

Fifth stage nymph.—The general colouration of the body develops a shining yellow tinge in the places where there were yellow and white patches in the previous stages. The orange coloured spots grow deeper in tinge. The size of the hopper increases, being about 25-27 mm. in length and 4·5-5 mm. in breadth. The antennæ (Plate XXIX, fig. 11) are fifteen-jointed and measure 7-8 mm. The third to tenth segments are laterally compressed and rhomboid in cross section ; those from eleven to fifteen are more or less cylindrical.

The anterior margin of the pronotum remains straight as in the previous stages but the posterior margin becomes convex at the middle. The wing pads get upturned in this stage, if they had not done so in the previous stage, and develop numerous unbranched veins. In the male, the subgenital plate reaches the supra anal plate (Plate XXX, fig. 3). In the female the ventral valves grow thicker and extend very much backwards, reaching the middle of the dorsal valves. The latter also grow and extend up to the tips of the podical plates. The egg guide (*eg*) is bigger and distinct (Plate XXX, fig. 11).

Sixth stage nymph.—The freshly moulted nymph of this stage (Plate XXIX, fig. 16) is lemon yellow in general colour with black markings. All the white patches of the previous stage become yellow and the black patches grow deeper in tinge. It measures about 35-43 mm. in length and 7·5 mm. in breadth. The description of this instar relates to those specimens which turn their wing pads in the fifth instar. It is noteworthy that the upturned state of wing-pads last in every case for two stages only, that is to say, the nymphs which turn their wings in the fourth stage become adult at the end of

the fifth stage after undergoing five moults only, and those which turn their wing-pads in the fifth stage become adult at the end of the sixth stage. The latter condition is more common than the former.

In this stage the eyes turn slightly bluish in colour and their transverse stripes disappear altogether. The antennæ measure 11-13·5 mm. and have fifteen or sixteen joints. The posterior margin of the pronotum grows backwards and covers the bases of the wing-pads, which in this stage are larger, thicker and dark blue in colour.

In the male, the subgenital plate becomes a conical, pouch-like organ into which the ædeagus is lodged. This plate extends beyond the extremities of the podical plates, hiding them from the ventral view, the margins of the supra anal plate being only visible (Plate XXX, fig. 4). In the female, the egg guide becomes fully developed and remains pushed in between the two ventral valves. The dorsal valves grow very thick and extend far beyond the podical plates. They develop a lateral fold externally. The ventral valves develop a transverse fold in the basal region and a vertical fold in each of the lateral lobes and thus appear to be made of several pieces (Plate XXX, fig. 11).

Just before the nymph is about to moult finally for attaining the adult stage its colour and different parts of the body undergo very well marked changes which can be easily made out through the old skin. All the black patterns on the body begin to turn bluish and all the orange and yellow spots fade away and instead continuous yellow patches on the blue background begin to appear. The basal region of the antennæ and the frontal ridge become bluish. The anterior half of the pronotum gets constricted, whereas the posterior half becomes broadened and blue in colour. The second pair of wing-pads begin to show a reddish tinge.

The ventral and dorsal valves of the ovipositor become highly chitinous. The tips of the latter curve upwards and their upper surface becomes broadly dentate. Each ventral valve develops a lateral tooth-like process in posterior region and a number of minute spines in the basal region. The lateral lobes of the ventral valves become very large and appear as distinct sclerities (Plate XXX, figs. 12 and 12-A.).

The final moult.—The process of final moulting is very interesting . The hopper, when about to moult, stops feeding and rests on a twig. It begins to contract and expand the anterior region of its body. The head is moved forwards and backwards and the pronotum is moved up and down by contraction of the cervical ampulla, causing the rupture of the skin along the medial line above the pronotum. This fissure gradually increases extending from the fastigium up to the wing-pads. The head and thorax begin to be gradually drawn out of the skin through the slit. The upturned wing-pads become horizontal in position and are drawn out of their sacs. The first and second pair of legs are then gradually drawn out. The third pair of leg is the last to come out. The cast skin is gradually left behind as the adult grasshopper draws itself out. During the whole process of moulting the hopper breaths hard and

keeps on expanding and contracting its body. Just after the moult the fore-wings are only partly expanded and the hind pair is folded like a fan. Gradually the wings are fluttered and raised vertically and within twenty to twenty-five minutes the elytra (fore wings) become fully expanded and develop bluish green colour with yellow veins and reticulations. The hind wings are hyaline to begin with but gradually develop a pink colour at the apex, which ultimately deepens into a red rosy colour. The insect then rests on the twig generally facing sunlight. A few minutes after, it starts feeding.

V. Control measures

Sprays

With a view to finding out some suitable insecticide for controlling this pest a number of stomach poisons were tried in the form of sprays, dusts and poison baits. Lead arsenate which is commonly used for such insects was not found effective either in the field or in the laboratory when sprayed at the usual concentration of 2 lbs. per 100 gallons of water. It did not kill any hoppers within ten to thirteen days. Between thirteen and sixteen days the mortality was 25 to 40 per cent. The hoppers were kept under observation in this and the following experiments for about sixteen days only because it was considered that if the poison would not kill the hoppers within a fortnight it would not have any practical utility.

In the control cage all hoppers were found living beyond sixteen days. The lead arsenite spray was prepared by dissolving 5 lbs. of stone-lime in 100 gallons of water to which 2 lbs. of powdered lead arsenate and 10 lbs. of *gur* were added and the whole mixture shaken thoroughly.

Sodium arsenite.—Sodium arsenite, which is a poison soluble in water, was found more effective. It was sprayed in laboratory cages at the rates of 2 lbs., 1 lb., and ½ lb. per 100 gallons of water. With the dose of 2 lbs., 96 per cent of the hoppers were killed in eleven days, death starting within two days of feeding, and the average longevity period being six days. This dose was however found to be injurious to the sprayed plants and hoppers did not feed readily on them. With the dose of 1 lb., the mortality was 100 per cent in thirteen days, the death starting within three days of feeding and the average life being 8·5 days. This dose also proved harmful to the leaves and the hoppers did not feed well on the sprayed food. With the dose of ½ lb. per 100 gallons, the leaves were not at all injured, but the rate of mortality was rather slow, being 90 per cent in twenty days, death starting within five days of feeding, and the average life being thirteen days. The hoppers fed moderately on the treated food. In the control cages all hoppers were alive after twenty days.

The above doses were repeated in the field on brinjal, castor, *jowar*, cucurbits, etc. The doses of 2 lbs. and 1 lb. per 100 gallons proved injurious to the leaves which moreover became unpalatable to the hoppers. The latter were present on the sprayed plants in less numbers on the next day. On the third or fourth day the treated plants were entirely devoid of hoppers

but a search for the dead ones did not reveal any carcases. With a dose of ½ lb per 100 gallons, there was no leaf injury. The hoppers were found feeding on the treated plants for a few days but gradually declined in numbers. However, the dead hoppers could not be traced easily, only one or two stray dead specimens being found under the plants here and there.

The sodium arsenite spray was prepared by dissolving 5 lbs. of lime and 1¼ lbs. of *gur* in 100 gallons of water and adding 2 lbs. of the poison. The spray was diluted twice or four times respectively when one lb. or ½ lb. doses were tried.

Calcium arsenite.—Calcium arsenite being insoluble in water does not affect the leaf tissue like sodium arsenite. It was used at the strengths of 2 lbs. and 1 lb. per 100 gallons of water. Both the strengths proved harmless to the leaves of *Calotropis*, cotton and oleander.

With a dose of 2 lbs., 95 per cent of the hoppers, feeding daily on the poisoned food, died in seven days in the laboratory cages, death starting within three days of spraying and the average life being five days. The hoppers however did not feed well on the sprayed food. Under field conditions 60 per cent of the hoppers feeding on the sprayed plants died within nine days, death starting within four days of feeding and the average life being 5·5 days. These hoppers had been allowed to remain on the sprayed plants in the field for thirty-six hours and then removed and put in the laboratory cages containing untreated food. The hoppers in the laboratory experiments were fed on sprayed food every day.

With a dose of 1 lb., the kill was 90 per cent in six days in the laboratory, the death starting within three days of feeding and the average life being four days.

Oleander plants were sprayed in the field with the above doses. The results were quite encouraging. The hoppers which had fed for forty hours on the sprayed plants, were removed and caged with sprayed food and about 90 per cent of them died in five days.

Dusting experiments

Sodium arsenite.—*Calotropis* and castor plants were dusted in the field with sodium arsenite mixed with lime in the proportion 1 : 4. The hoppers were collected after twenty-four hours of dusting and caged. From the treated plants only 33 per cent of hoppers died in six days, and the rest continued to live beyond sixteen days. They started dying on the fourth day after dusting. The leaves of *Calotropis* seemed more or less unaffected but those of castor plant showed a scorching effect.

Calcium arsenite.—Calcium arsenite dusted in the same proportion showed slightly better results. The leaves were not injured and about 50 per cent of hoppers died in five days. The remaining lived beyond sixteen days.

Paris green.—Paris green was mixed with fine wood ashes in the proportion of 1 : 8 and 1 : 16, and dusted over the *Calotropis* and oleander plants Hoppers were allowed to feed for twenty-four hours on the dusted plant.

With a dose of 1 : 8, 60 per cent of the hoppers died in ten days, the remaining living beyond sixteen days. Hoppers started dying on the third day after dusting.

Sodium fluosilicate and lime in the proportion of 1 : 4 were similarly dusted on brinjal plants but very few hoppers were killed.

Baits

Sodium fluosilicate.—This bait was prepared in the usual way. One lb. of finely powdered sodium fluosilicate was mixed thoroughly with 20 lbs. of wheat bran ; 1 lb. of *gur* or 1 pint of molasses was dissolved in a small quantity of water and added to the bran mixture so as to make it into a crumbly mass. Some amyl acetate was added to give the bait a good smell of ripe banana fruits. The bait was scattered in the hopper-infested field but did not prove effective. The hoppers, which, as already described, seldom leave the plant and come down on the soil, did not take to the bait scattered on the ground. The hoppers kept in cages in the laboratory also did not feed on the bait.

Conclusion

Experiments described above show that the spraying of infested plants with calcium or sodium arsenite at the rate of 1 lb. and ½ lb. per 100 gallons of water respectively seems to be the most satisfactory method of control.

VI. Summary

The grasshopper *Poecilocerus pictus* has been known to feed mostly on *ak* plant (*Calotropis* sp.), which is hardly of any economic value, but in the summer of 1937 it was found attacking brinjal and castor in a village garden near the estate of the Imperial Agricultural Research Institute.

Numerous food plants of economic value were tested in 1937 and 1938 to determine the potentialities of this new pest of cultivated crops. It is found that this grasshopper readily feeds on brinjal (leaves and fruits), tomato, castor, *bhindi*, oleandar, etc.

The seasonal-and life-histories and general bionomics of the grasshopper have been studied. The hoppers undergo five or six moults before becoming adult. The various instars have been described.

Several stomach poisons have been tested as sprays, dusts and baits. Spraying with sodium arsenite at the rate of half pound per 100 gallons of water has proved to be the most satisfactory method of control. Sodium fluosilicate bait, which is usually effective against surface grasshoppers, has not been found satisfactory due to the peculiar habits of the grasshopper.

REFERENCES

Fletcher, T. Bainbrigge (1914). "Some South Indian Insects." Madras ; 1914.

Uvarov, B. (1928). "Locusts and Grasshoppers." London ; 1928.

GIPD—3 S—39 IC of AR—15-9-39—88.

CHILO TRYPETES BISSET (PYRALIDAE)—A NEW PEST OF SUGARCANE FROM THE PUNJAB

CHILO TRYPETES BISSET (PYRALIDAE)—A NEW PEST OF SUGARCANE FROM THE PUNJAB

BY

KHAN A. RAHMAN, B.Sc. (EDIN.), PH.D. (CANTAB.), F.R.E.S.

AND

D. N. TANDON, L.AG., B.Sc. (AGRI.)

Punjab Agricultural College, Lyallpur

(Received for publication on 29 November 1939)

(With Plate XXXVIII)

INTRODUCTION

IN India sugarcane is damaged by several caterpillars of pyralid moths. M. Afzal Husain, Entomologist to Government, Punjab, Lyallpur studied the distribution of these borers in the Punjab in 1923 by examining sugarcane samples from all over the sugarcane-growing tracts of the province. A variety of *barani* (rain-fed) sugarcane grown locally at Sialkot yielded a species of caterpillars which was different from the common species of sugarcane borers. M. Afzal Husain gave this caterpillar the name of ' new pyralid borer '. Moths were bred out and submitted to the Imperial Research Institute, Pusa and British Museum, London, for identification. In spite of repeated submissions of fresh material annually, the pest remained unnamed till October 1938, when the senior author wrote to Sir Guy Marshall for its specific identification. This resulted in Mr G. A. Bisset naming it as *Chilo trypetes* sp. nov. (Pyralidae : Lepidoptera).

DISTRIBUTION

Chilo trypetes Bisset has a restricted distribution in the Punjab and has so far been recorded from the tehsils of Pathankot, Batala, and Gurdaspur (Gurdaspur district), and Mukerian (Hoshiarpur district).

FOOD-PLANTS

The pest is monophagous and feeds only on sugarcane. It has neither been found in other gramineous plants (cultivated or wild) in the fields, nor has it ever fed on such plants as guinae grass (*Pannicum maximum*), maize (*Zea Mays*), *sarkanda* (*Saccharum sara*) and a few wild grasses offered to it in the laboratory.

CHILO TRYPETES BISSET

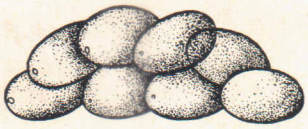


FIG. 1. Egg cluster

FIG. 2. Full-grown caterpillar ($\times 2\frac{1}{4}$)

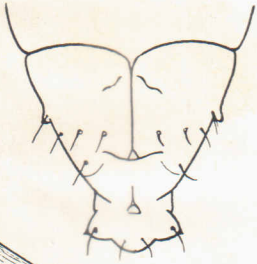


FIG. 3 *a*. Tip of abdomen of pupa (highly magnified)

FIG. 3. Pupa ($\times 2\frac{1}{4}$)

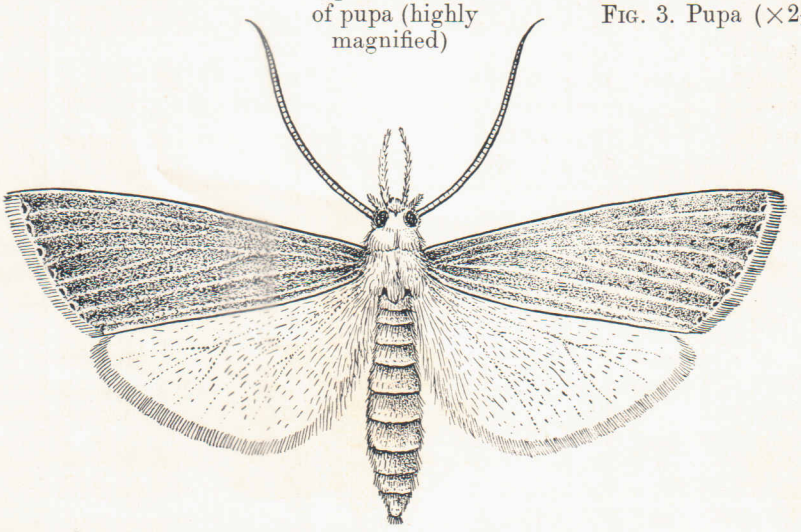


FIG. 4. Adult female ($\times 2\frac{1}{4}$)

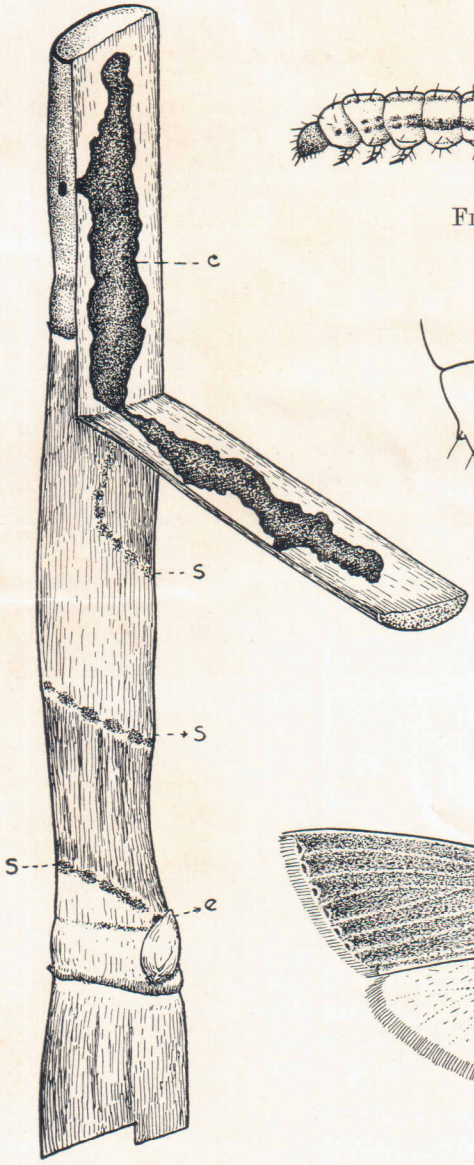


FIG. 5. Damaged cane shoot ($\times \frac{1}{2}$)

Description of various stages

Egg (*Plate* XXXVIII, fig. 1*)

Length 0·65-0·86 mm., breadth 0·42-0·53. Flattened and scale-like. Glistening white to pale cream when freshly laid, changing to dark grey before hatching.

Caterpillar (*Plate XXXVIII, fig. 2*)

A full-grown caterpillar measures 25-28 mm. in length and 2·5-3·0 mm. in breadth. Body cylindrical, sparingly clothed in short setae which arise from tubercles. Head light orange, rest of the body creamy white ornamented with four longitudinal reddish-brown stripes situated as follows : One on each side along the spiracles and the other on either side of the dorsal vessel; the spiracular (or lateral) stripes being very prominent, particularly between the 1st and 9th abdominal segments. Crochets on prolegs are arranged in uniordinal uniserial circle.

Pupa (*Plate XXXVIII, figs. 3 and 3a*)

Length 14-19 mm., breadth 2·3-3·0 mm. Body more or less smooth, creamy white when freshly formed, but later on changes to yellowish-brown. Thorax with a dorsal median longitudinal ridge. Abdominal spiracles oval slightly raised and deep brown in colour. Spiracular reddish-brown stripes faintly indicated. Last abdominal segment terminating in a prominent broad ridge, distal margin of which is armed with three small spines as indicated in Plate XXXVIII, fig. 3*a*.

Adult (*Plate XXXVIII, fig. 4*)

G. A. Bisset [1939] describes the moth as follows :

Male.—25-27 mm. Dorsal and lateral surfaces of the palpi, thorax, abdomen and the upper surface of the fore-wing with seven darkish spots between the veins. Under-surfaces lighter to white. Hind wings white. Labial palpi projecting forwards more than twice the length of the head ; second segment twice as long as third. Head with a conical prominence ending in a short point ; undersides of prominence flattened, the edge of the flat surface being slightly produced in front to a point directly beneath the other. Antennae serrate and finely ciliated.

Female.—29-32 mm. Similar to male but fewer dusky brown scales on the fore-wing and the antennae simple.

Life-history

The moth forces its way out of its pupal cell through the protected exit hole made for the purpose by the caterpillar before pupation. The adults become active at night when they mate, copulation lasting ten to twenty-three minutes.

* Sketches presented in Plate XXXVIII were made by M. D. Siddiqi, Artist, Entomological Section, Lyallpur, under the supervision of the senior author.

A female lays her eggs in clusters at night on the leaf-sheath near the upper nodal rings of the stem. They are arranged in rows and overlap each other like the scales on a bird's leg (Plate XXXVIII, fig. 1). Each egg-cluster contains three to sixty-five eggs.

The number of eggs laid by a female varies greatly (Table I).

TABLE I

Oviposition record of Chilo trypetes *Bisset at Gurdaspur*

Number	Pairs sleeved		Total number of eggs laid
	From	To	
1	31 July	4 Aug.	105
2	4 Aug.	8 Aug.	182
3	6 Aug.	10 Aug.	230
4	7 Aug.	12 Aug.	113
5	8 Aug.	12 Aug.	198

Thus a female is capable of laying 230 eggs in her life-time.

The eggs usually hatch in the morning. The egg-stage occupies nine to eleven days (Table II).

TABLE II

Duration (in days) of egg-stage of Chilo trypetes *Bisset at Gurdaspur*

Number	Eggs laid	Eggs hatched	Duration of egg-stage
			Days
1	4 Aug.	14 Aug.	10
2	5 Aug.	15 Aug.	10
3	9 Aug.	19 Aug.	10
4	13 Aug.	22 Aug.	9
5	16 Aug.	26 Aug.	10
6	19 Aug.	30 Aug.	11
7	20 Aug.	30 Aug.	10

The larval stage lasts for forty-eight to sixty-four days (Table III).

TABLE III

Duration (in days) of larval stage of Chilo trypetes *Bisset at Gurdaspur*

Number	Eggs hatched	Larvae pupated	Duration of larval stage
			Days
1	3 July	5 Sept.	64
2	14 July	31 Aug.	48
3	12 Aug.	5 Oct.	54
4	14 Aug.	5 Oct.	52

Prior to entering into pupation a full-grown caterpillar constructs a pupal cell in the burrow in which it was feeding. The cell is internally lined with silken threads. It also provides the cell with an exit hole by cutting out a small circular piece from the rind of sugarcane stem and covering the hole thus made by a silken web. Afterwards it transforms itself into a pupa Table IV gives the duration of the pupal stage.

TABLE IV

Duration (in days) of pupal stage of Chilo trypetes *Bisset at Gurdaspur*

Number	Larvae pupated	Adults emerged	Duration of pupal stage
			Days
1	2 Aug.	10 Aug.	8
2	4 Aug.	17 Aug.	13
3	9 Aug.	15 Aug.	6
4	3 Aug.	12 Aug.	9

SEASONAL HISTORY

The adults appear on the wing during June-July, deposit eggs and start the infestation. From July to October all stages of *Chilo trypetes* Bisset are met with in the fields, the pest completing one generation during this period. The moths of the second generation start emergence about September when they lay eggs and the caterpillars hatching out of these eggs descend to the basal portion of the cane in November where they remain till the following June.

Nature and extent of damage

Chilo trypetes Bisset starts taking toll of the crop when the plants are fairly grown up and the internodes are well formed.

The mode of entry of the caterpillars into the stem of sugarcane is quite peculiar. On hatching from the eggs they feed for a while on the buds situated on the top first or second internode and then they bore into it (internode) from near the buds (Plate XXXVIII, fig. 5*e*). They feed on the tissue first below the rind boring their way upwards (from the point of entry) in a spiral manner (Plate XXXVIII, fig. 5*s*) : externally this passage appears as a dark spiral streak, which on closer examination is found to be made up of a series of punctures (made by the caterpillars) lying side by side like the beads in a rosary. When about two-thirds of the internode is damaged in this manner, the caterpillars bore deeper into the softer tissue of the cane and feed by making a single, straight and central tunnel (Plate XXXVIII, fig. 5*c*).

Up to the second moult the caterpillars feed gregariously when there may be twenty-seven to forty-two of them in a single bore. Afterwards they disperse and lead a solitary life.

Injury by this borer is quite characteristic. In the beginning of the attack (i.e. when the caterpillars are feeding just below the rind (Plate XXXVIII, fig. 5*s*) the side leaves wither, but as the attack proceeds further (i.e. when the caterpillars have made a central bore (Plate XXXVIII, fig. 5*c*), the entire whorl of the leaves (including the central leaves) dries up and the crop presents a blasted appearance.* The attacked canes fail to grow. The dark spiral streak (Plate XXXVIII, fig. 5*s*) renders the affected internode weak, which breaks off easily when shaken by wind or a passing animal.

The damage by *Chilo trypetes* Bisset ranges from 15 to 20 per cent of the total crop during normal years, but in years of serious damage it may be as high as 50 per cent. The damage by this pest is at its maximum during August-September. *Barani* (rain-fed) crop suffers the most and, of the various Coimbatore varieties of sugarcane, Co 205 and Co 285 are the worst sufferers.

Control

Chilo trypetes Bisset is not a difficult pest to control. As mentioned above it spends the period from November to June as a resting caterpillar in sugarcane stubbles. Therefore simple, cheap and most effective method to deal with it is to plough up the sugarcane stubbles any time from November to May with a furrow turning plough. The uprooted stubbles should be collected and destroyed whenever convenient before June. A clean-up campaign in the localities where it is a serious pest will prove very helpful in subjugating it. If possible ratooning of sugarcane in infested areas should be given up.

When the attack is in progress all the damaged top shoots, recognisable by the symptoms described above, should be collected and destroyed. This is best done during July when the young caterpillars are feeding gregariously inside the top shoots.

* In case of attack by other borers it is only the central shoot that dries up and is called a ' dead-heart ', the rest of the leaves remaining quite healthy and green.

TABLE I

Percentage of parasitization of S. nivella *Fab. eggs by* T. beneficiens *Zehnt. at Jullundur*

Month	Number of host eggs examined	Number of host eggs found parasitized	Percentage parasitization
February .	830	148	17·8
March .	961	181	19·9
April .	339	173	51·0
May .	1,385	24	1·7
June .	439	*Nil*	*Nil*
July .	1,606	53	3·3
August .	1,821	848	46·6
September	27	14	52·0
October .	1,401	961	68·6

2. Family Chalcididae

Trichogramma 2 spp.

Distribution.—These parasites are common throughout the Punjab.

Insect hosts.—Two species of *Trichogramma* (not yet specifically identified) have been bred out in the Punjab from the eggs of *Argyria sticticraspis* Hampsn., *Chilo zonellus* Swinh., *Sesamia uniformis* Dudgn., and *Emmalocera depresella* Swinh.

Bionomics.—*Trichogramma* spp. are active during March-October. The period of their greatest abundance, however, is September-October, when in certain years they may parasitize 90 per cent of the host eggs. One of these two species of *Trichogramma* completes its life-cycle in the eggs of *Argyria* in about six days at 90°-98°F.

Elasmus zehntneri Ferr.

Distribution.—This parasite has so far been reported from Jullundur, Lyallpur and Sonepat.

Insect host.—It parasitizes only the full-grown larvae of *Scirpophaga nivella* Fab.

Bionomics.—*E. zehntneri* Ferr. is most active during July-February. The female selects a mature caterpillar for oviposition, stings it into a state of torpidity and lays its eggs in a cluster besides it. On hatching, the parasite larvae feed on the body juices of the paralysed host caterpillar, and when full-fed, they pupate in the tunnel (in which the host caterpillar was feeding in the stem of sugarcane) without cocoons.

THE IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH

Entomological Investigations on the Leaf-curl Disease of Tobacco in Northern India, III. The Transmission of Leaf-curl by White-fly, *Bemisia gossypiperda*, to Tobacco, Sann-hemp and a New Alternate Host of the Leaf-curl Virus

BY

HEM SINGH PRUTHI

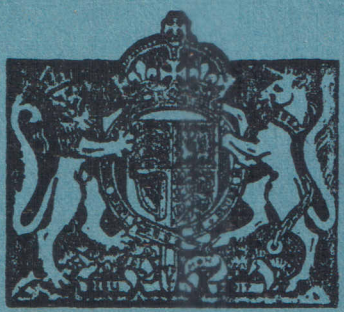
AND

C. K. SAMUEL

Reprinted from

The Indian Journal of Agricultural Science

Vol. IX, Part II, April, 1939



PUBLISHED BY THE MANAGER OF PUBLICATIONS, DELHI.
PRINTED BY THE MANAGER, GOVERNMENT OF INDIA PRESS, NEW DELHI
1939

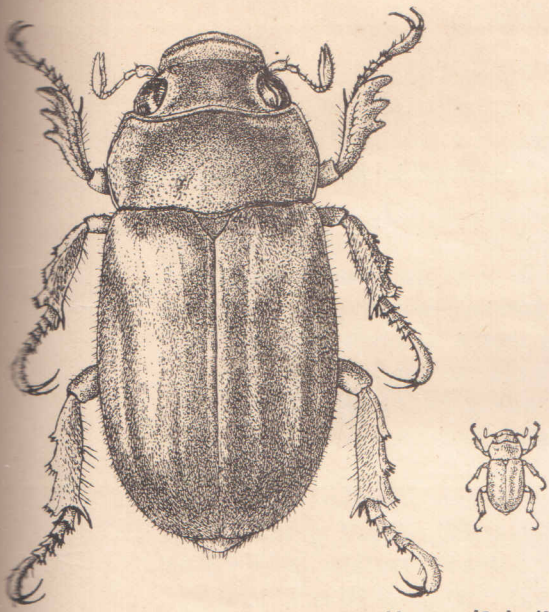


Fig. 1.—*Adoretus versutus*, Harold (magnified ; the smaller figure shows the natural size).

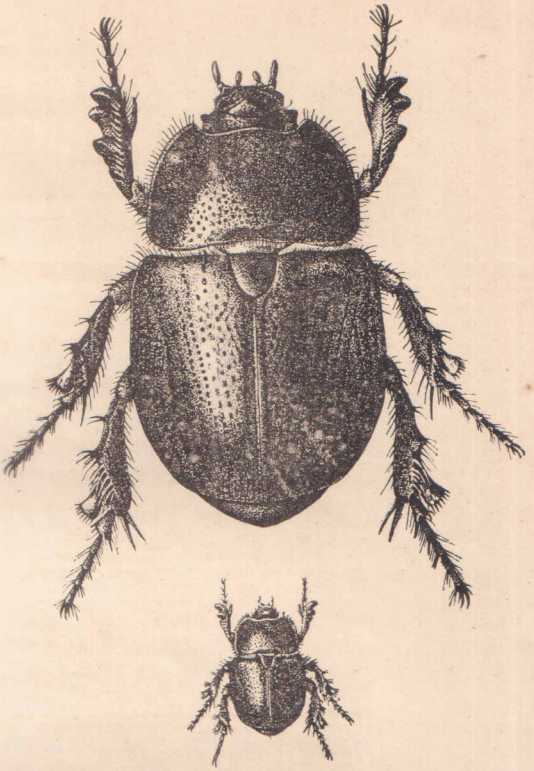
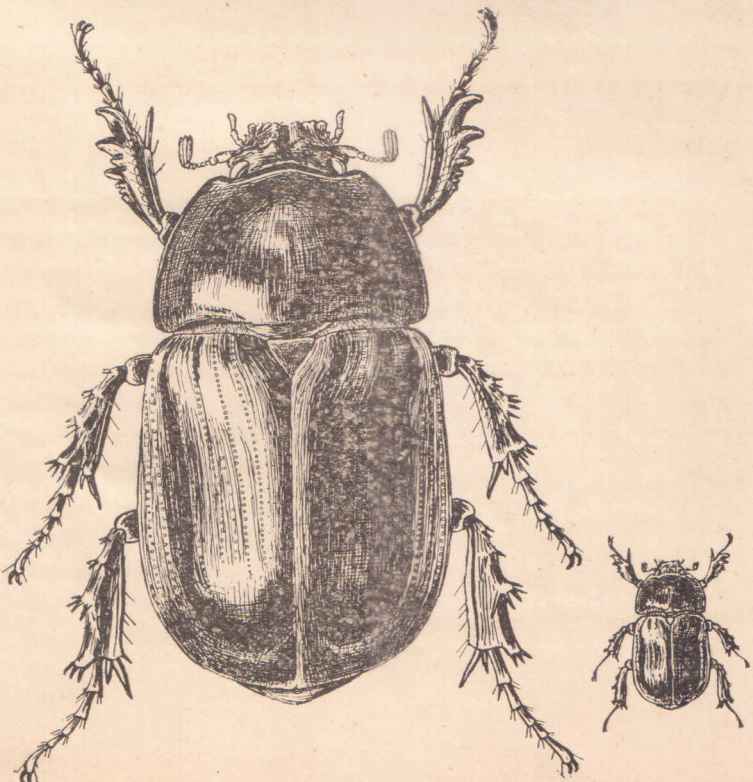


Fig. 2.—*Pentodon bispinifrons* (magnified ; the smaller figure shows the natural size).



Beetles.

The following beetles have been definitely observed to be capable of injuring gramineous plants in most cases with external symptoms similar to those caused by borers :—

Oryctes rhinocerus gnawing sugarcane setts and shoots at Coimbatore and in Travancore. (*South Indian Insects*, p. 151).

Xylotrupes gideon is known to attack sugarcane in this manner.

Alissonotum impressicolle caused serious damage to sugarcane in the Kamrup Farm in Assam in April-May in 1919 by gnawing young shoots and boring into setts and ratoon stumps. It did similar damage to thick grasses also.

Alissonotum piceum did similar damage as the above in the Kamrup Farm.

Heteronychus sublævis worked in company with the above two in the Kamrup Farm. (Plate XVI, fig. 3.)

Heteronychus sacchari recorded to have caused extensive damage to sugarcane in Rangpur. (F. I. Coleopt. *Lamellicornia*, pt. I, p. 297).

Pentodon bengalense, Arrow, gnawed into sugarcane shoots and setts in Tarnab Farm at Peshawar in May 1912.

Pentodon bispinifrons recorded to have occurred on sugarcane at Baroda, apparently causing similar damage as the above.

Phyllognathus dionysius reported to cut stems of young paddy plants in South Kanara.

Autoserica sp. observed to gnaw into sugarcane shoots in March at Pusa.

Apogonia proxima observed to live among the roots and feed on the shoots of *Saccharum spontaneum* at Pusa.

Protætia alboguttata observed at Pusa to feed similarly on *Panicum* shoots.

The beetles named above work underground and feed as shown in our former Plate. Other beetles and weevils are known to feed on gramineous plants, usually eating leaves or new shoots. Although they may cause a set back to the growth of the plants they do not kill them. The following may be mentioned :—

Tanymecus indicus is known to nibble wheat seedlings in the Punjab and *juar* (*Andropogon sorghum*) seedlings in Surat.

Tanymecus hispidus occurred in large numbers in Messrs. Turner, Morrison & Co.'s sugarcane plantations in Cooch Behar.

Tanymecus sciurus was observed by P. C. Sen to eat tender leaves of young sugarcane shoots at Rangpur.

Myllocerus blandus is commonly found feeding on tender leaves of young sugarcane, maize, wheat, rice, etc.

Myllocerus discolor and *M. 11—pustulatus* also feed like *M. blandus*.

Gonocephalum hofmannseggi, Steven., has been recorded as a pest of *Eleusine coracana* in Mysore, (Mysore Bull, No. 5, by Messrs. Coleman and Kunhi Kannan).

The Dynastine beetles may be looked upon as serious pests. Although they may not occur as regular pests they are capable of doing serious and extensive damage, as will appear from the following account of beetle pests in the sugarcane farm at Kamrup, Assam.

The Kamrup Farm is situated in the midst of an extensive piece of waste land running along the base of the Bhutan Hills and having on it a thick and mixed growth of various kinds of tall grasses. About 50,000 acres of this land is said to be capable of being rendered arable. The Farm has brought under cultivation about 800 acres divided into 18 blocks, *viz.*, 6 blocks of 60 acres, 2 blocks of 55 acres, one block of 54 acres, 2 blocks of 42 acres, one block of 34 acres, 2 blocks of 30 acres, one block of 25 acres, one block of 16 acres, one block of 15 acres and one block of 11 acres. In 1919 there were 241 acres of plant cane and 229 acres of ratoon cane. In the other plots *Sesbania* was being grown for green manuring.

The sugarcane of the entire Farm was remarkably free from borers (5th to 15th May 1919). The damage was due entirely to three species of black beetles, *viz.*, *Alissonotum impressicolle*, *A. piceum* and *Heteronychus sublævis*. They worked underground chewing and gnawing into the bases of young canes which in extreme cases were almost wholly cut across. Young buds which were somewhat grown but had not yet emerged out of the ground were also similarly destroyed. The beetles bored into setts and also into the bases of canes already formed. This form of damage to sugarcane by adult beetles on such a scale had never before been observed although sporadic cases were known as described above.

The relative abundance of the three species can be judged from the number obtained of each out of a total collection of 286 made at random in the second week of May 1919.

Alissonotum impressicolle	264
„ *piceum*	19
Heteronychus sublævis	3

They were first observed on the 10th April. They spread over the whole locality and the Farm area received its share. They did not

come to sugarcane by choice. They were equally or rather more common among the grasses surrounding the Farm and also among the grasses growing on roads running between and bordering the various blocks. Similarly they were found among grasses growing in the blocks sown with *Sesbania* (*Dhaincha*). Among sugarcane also they were practically equally prevalent in blocks which had good and apparently healthy crops, as in those which seemed to have suffered badly.

Actually however a slight difference was observed in their distribution in the different parts of the blocks. Parts where many shoots were growing had attracted more beetles. The beetles also seemed to be somewhat gregarious in habit. Among some ratoon stools as well as among some stools of the plant cane as many as 10, 15 or even 20 beetles were present. Similarly among individual grass stools on the roads of the Farm as well as outside the Farm up to 34 beetles were observed to have congregated. The number of beetles in parts of the plant cane with poor and patchy germination was much less. But a single beetle was enough to kill the solitary shoots. Where germination was extremely poor the number of beetles was still less as there was hardly anything above ground to attract them. In such parts the setts were observed to have been bored by stray beetles here and there.

It was evident that after having swarmed and spread once, the beetles did not migrate again from places where they happened to alight. It was ascertained by examination that many beetles were present underground in the South-eastern part of Block III. No hole could be observed in the surface of the soil which had been beaten down by rain. The surface was examined very carefully at night with lantern in hand. It was clear that no beetle was going out.

The beetles were mainly attracted by and fed upon new and growing shoots. Among plant canes after having fed on the shoots they went into setts if they wanted to feed longer. Similarly among ratoons they did not attack the stumps unless forced to do so for want of growing shoots.

The beetles fed for a short time after swarming and then they rested. They were not attracted to strong electric lights, nor to a bait of molasses, country liquor and ethyl acetate.

The Farm was started in 1915 and from records of rainfall kept from April 1915 it was found that from February till October the rain was fairly well distributed in 1916, 1917 and 1918. In 1919 however there was hardly any rain till 5th April.

The primary cause of the trouble was the droughty condition which prevailed up to 5th April. Parts of the Farm where the soil retained

moisture of the previous year better had a fair crop. When no moisture was retained germination was poor or extremely patchy. The sett canes in such parts lying near the surface within about two inches or less below the surface were affected by the drought and most were rotting. The beetles did not interfere with germination. They were common all over the Farm, in fact more common in parts which had a good to fair crop than in parts which had a poor crop. When the crop grew normally and tillered well the attack was hidden or rather the crop outgrew the attack.

The beetles were not new to the locality. They breed among the grass roots. In previous years normal growth of the crop consequent on the normal climatic conditions hid the attack of the beetles which did not therefore attract attention. In 1919 the local authorities estimated the damage at over 60 per cent. and ascribed the whole of this loss to the beetles. They came to this conclusion on superficial observation of the conditions. Mr. S. R. Gupta, Entomological Assistant, Assam, and the writer very carefully examined all the plots and found that the beetles were certainly responsible for about 20 per cent. of the total damage. The failure of the setts to germinate owing to adverse climatic conditions could not be ascribed to the beetles. A careful examination of the conditions led to the conclusion that in years with normal climatic conditions the beetles would not prove injurious to the sugarcane of the Farm. This was corroborated in 1920 when although Mr. Gupta found the beetles to occur in practically equally large numbers as in 1919 much damage was not caused.

Apart from their capacity to cause damage directly, the beetles and beetle grubs and in fact all the external agents of damage are responsible for probably much greater damage indirectly by affording places for the entry of fungal diseases through bites on the surface of the stems. " Chewing " described at page 361 of the first paper (Proc. Third Entl. Meeting) may be referred to in this connection.

Some beetle grubs and beetles have already proved to be very serious pests and others may certainly be looked upon as potential pests of this nature. All possible precautions should be taken against importing them into new localities. They have the chance of insidiously coming in the earth taken with plants and cuttings. To point to notable instances of this nature one has only to make mention of the entry of *Oryctes rhinoceros* into Samoa, believed to have been carried in the earth taken with rubber plants from Ceylon, and of the importation of *Phytalus smithi* into Mauritius with sugarcane cuttings from Barbados.

The Borers.

The following additions should be made to the list given in the first paper :—

Coleoptera.

Lamiadæ : Lychrosis zebrinus. (C. S. 2010).
Chrysomelidæ : Chætocnema sp. (C. S. 1891, 1923, 2043).
Scolytidæ : Xyleborus perforans, Woll.
Pyralidæ : Hypsotropa tenuinervella, Raq. (C. S. 1920).
Chilo torrentellus, Meyr. (C. S. 2027).
Crambus corticellus, Hmpsn. (C. S. 2007).
Saluria inficita, Wlk.
Gelechiadæ : Ephysteris chersœa, Meyr. (C. S. 2046).

Potential Coleopterous borers. There is reason to believe that the Curculionid and Scolytid beetles which have of late been observed to breed in date and coconut palms in such large numbers as to bring about the death of these plants, may turn their attention to sugarcane. *Calandra stigmaticollis*, which is reported to be bad in this respect in Ratnagiri and Malabar, has been observed in the Insectary to oviposit, live and breed in sugarcane stems without any apparent inconvenience. Among Scolytid beetles, *Xyleborus perforans* already ranks as a pest of sugarcane. Therefore wherever such affected palms are present, they may be looked upon as sources of danger, not only to other palms but also to sugarcane, especially thick varieties of sugarcane. A Nitidulid beetle, *Brachypeplus* sp. (C. S. 1101 and 1661), is frequently found breeding inside decaying but moist stems of sugarcane and maize. But it is not a borer.

Foodplants.

I. Cultivated crops.

The following insects should be added to the lists under the different crops given in the first paper :—

Sugarcane—
Xyleborus perforans.

Rice—
Ephysteris chersœa.
Chætocnema sp.
Phycitid borer (C. S. 1837).

Marua (*Eleusine coracana*) :
Saluria inficita.

Kauni (*Setaria italica*) :
Sesamia inferens.

China (*Panicum miliaceum*) :
Chætocnema sp.

III. *Semi-cultivated plants.*

Under this heading the following plant is added as it is grown in gardens and is of economic importance :—

Lemon grass : *Sesamia inferens.*

Also the following insects are added to the lists given in the first paper :—

Ikri (*Saccharum fuscum*) :
Curculionid borer (C. S. 1778).
Batri (*Saccharum spontaneum batri*) :
Chilo torrentellus.
Lychrosis zebrinus.

IV. *Wild grasses and plants*

The following additions are made :—

Katra (*Andropogon squarrosus*) :
Hypsotropa tenuinervella.
Procometis trochala. (Plate XVII.)
The Noctuid borer (C. S. 1666).
Rosha grass (*Cymbopogon schœnanthus*) :
Hypsotropa tenuinervella.
Scirpus corymbosus :
Crambus corticellus.
Coix lachryma-jobi var. *aquatica* :
Chilo simplex.

Differentiation of borers.

The following addition should be made to the key for larvæ :—

3. Caterpillar with grey transverse bands on segments . *Ephysteris chersœa.*
4. G. (*Saluria inficita* is to be placed in this group) . ...
   J. Colour creamy yellow. Shape hardly tapering. The segments with rather an elongated appearance and their surfaces rather chitinized and shiny . . . . . *Chilo torrentellus.*
   K. Colour ordinarily red but pale yellow in pupating and hibernating caterpillars . . . . *Hypsotropa tenuinervella.*

Crambus corticellus will come under 11 but cannot be definitely placed until further material is available.

A revised key for differentiating the pupæ is given below and supersedes that in the first paper. The pupæ of the caterpillars grouped according to colour above are not likely to be confused with those of *Chilo, Diatræa* and *Argyria.* For the same reason *Raphimetopus* (*Anerastia*) *ablutella* is also omitted.

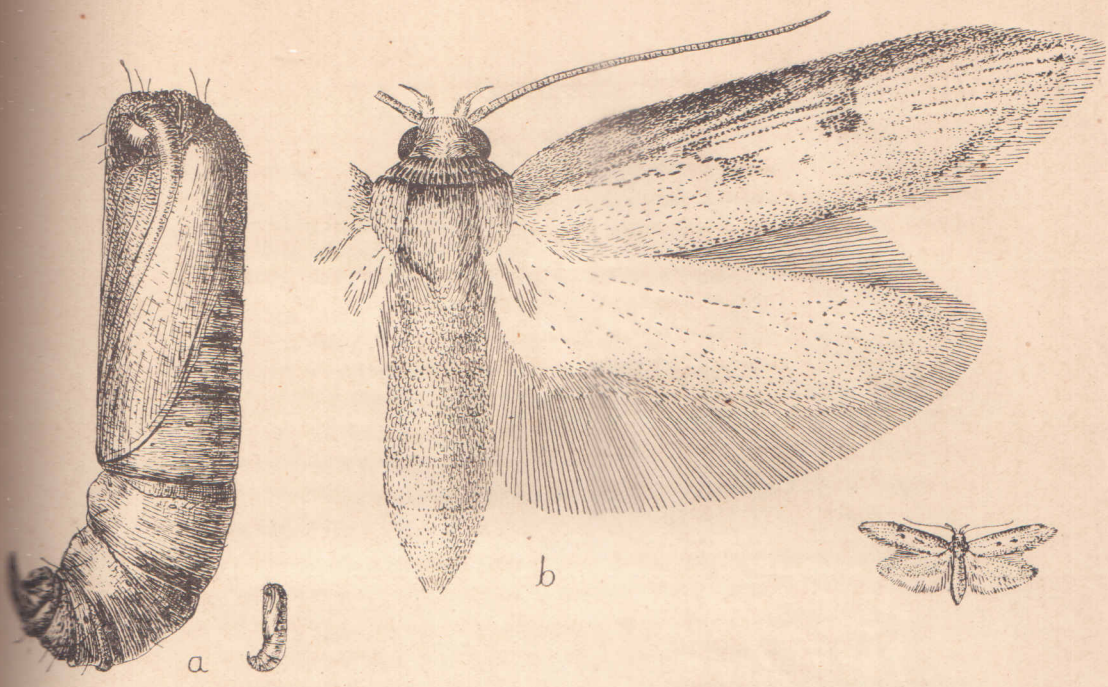


Fig. 1.—*a*, pupa ; *b*, Moth (magnified ; the smaller figures show the natural sizes).

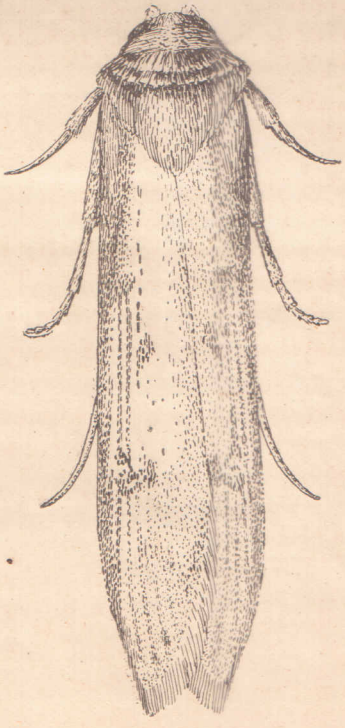


Fig. 2.—Moth, resting position (magnified).

Procometis trochala, Meyr.

Key to Pupæ of Borers.

1	Larval tubercles (bases of hairs) converted into spines on the body of the pupa	2
	Without such spines on pupa	3
2	The protuberant part of the hind end of pupa is broader than long and has two indentations on the tip, each indentation having in it a short spine surmounted with a hair	C. S. 1835
	The protuberant part of the hind end of pupa is conical and has no spines of any kind	*Chilo torrentellus.*
3	Without ridges or hooks or apparent roughness on 7th abdominal segment	4
	Pupa with such	5
4	The hind end having distinct spines	C. S. 1677
	The hind end having no spine. The dorsal part of the hind end is protruded and the protruded part has a clean rounded margin	*Crambus corticellus.*
5	With complete circle of ridges, spines or roughness on 7th abdominal segment	6
	With incomplete circle as above	7
6	Circle composed of distinct and separate spines	(C. S. 1610) *Argyria tumidicostalis.*
	Circle of flattened ringlike ridges more or less joined to one another	(C. S. 1560). *Diatræa auricilia*
7	Incomplete circle of distinct spines	C. S. 1674.
	Incomplete circle of roughness without distinct spines	8
8	Dorsal half of anal end with six spines in two groups of three triangularly arranged	*Chilo simplex.*
	Dorsal half of anal end with four spines	9
9	The spines situated on dorsal margin and pointing more or less backwards (dorsally)	10
	The spines situated on tip and pointing posteriorly	*Diatræa venosata.*
10	The ridge of roughness on 7th abdominal segment extending towards the ventral surface beyond the spiracles	C. S. 1769.
	Extending up to the spiracles	C. S. 1795.
	Not extending up to the spiracles	C. S. 1831.

Life Histories of the Borers.

Pachydiplosis oryzæ.

This is a small mosquito-like fly the larva of which feeds inside rice plants and causes the growth of a long tubelike gall in place of the stem. The stem being thus destroyed, the affected plants do not produce any ear. This disease has been referred to in the first paper and a coloured plate has been given there showing galls and the different stages of the fly. The disease has been known to exist in Madras, Western Bengal and Bihar and Orissa for a very long time. It is, however, only recently that its real nature and the agency causing it

have come to light. It is known under various names, all descriptive of the outward symptom of the disease. Some of these names are given below with the localities where they are prevalent.

In Tamil districts of Madras :—
Anaikombu (Elephant tusk).
Thandeethu (bearing of earless stalks).

In Telugu districts of Madras :—
Kodu.
Koyyala Tegulu (stick disease).

In South-Kanara district—
Kane.

In parts of Orissa (Angul, Cuttack) :—
Thenga (rod).
Penkalia (flute-shaped).
Kalia (cigar-shaped).
Sunda (Tusk ; rod).

In Chota Nagpur in Bihar and Orissa :—
Auræia.
Bhenku.
Khorka (stick).
Sanhra (twining male, as no ear is produced ; Sanhr = bull).

In parts of West Bengal (Burdwan and Bankura)—
Bhenpu or *Bhepu* (pipe).
Khorka (stick).
Khorka-mara or *Khorkadhara* (affected with *Khorka* disease).

The first authentic record of the occurrence of this disease was made in October 1880, when the Magistrate of Monghyr in Bihar reported serious injury to paddy in a particular part of the district. (*Ind. Mus. Notes*, Vol. I, p. 103.) The next record is in the report of the Agricultural Chemist, Mysore State, for 1901-02. In that year it occurred in a large area several square miles in extent in Mysore district and the attack was a very severe one causing enormous aggregate loss to the *raiyats*.

Since 1913 it has been reported from various places in Bengal, Bihar and Orissa and Madras. As a result of the attention paid to it the following facts have been gathered.

The Fly appears in August and September and sometimes as late as October. It may be present earlier in the season but it is about this time that it occurs in sufficient numbers to attract attention and in some years in large numbers, large enough to cause serious damage.

ENTOMOLOGICAL INVESTIGATIONS ON THE LEAF-CURL DISEASE OF TOBACCO IN NORTHERN INDIA

III. THE TRANSMISSION OF LEAF-CURL BY WHITE-FLY, *BEMISIA GOSSYPIPERDA*, TO TOBACCO, SANN-HEMP AND A NEW ALTERNATE HOST OF THE LEAF-CURL VIRUS

BY

HEM SINGH PRUTHI, M.Sc., PH.D. (CANTAB.), F.N.I.

Imperial Entomologist

AND

C. K. SAMUEL, B.Sc.

Assistant Entomologist, Tobacco Research Scheme, Imperial Agricultural Research Institute, New Delhi*

(Received for publication on 22nd June 1938)

(With Plates VII-X and one text-figure)

CONTENTS

		PAGE
I.	INTRODUCTION	224
II.	TECHNIQUE, MATERIAL, ETC.	224
III.	TRANSMISSION OF THE DISEASE FROM SANN-HEMP TO TOBACCO	226
IV.	TRANSMISSION OF THE DISEASE FROM TOBACCO TO SANN-HEMP	229
V.	TRANSMISSION OF THE DISEASE FROM SANN-HEMP TO SANN-HEMP	231
VI.	TRANSMISSION OF THE DISEASE FROM TOBACCO TO TOBACCO	232
VII.	*AGERATUM CONYZOIDES*, A NEW IMPORTANT HOST OF THE TOBACCO LEAF-CURL VIRUS	235
VIII.	TRANSMISSION OF THE DISEASE FROM TOBACCO TO *AGERATUM CONYZOIDES*	236
IX.	TRANSMISSION OF THE DISEASE FROM *AGERATUM CONYZOIDES* TO SANN-HEMP AND BACK TO THE WEED	236
X.	TRANSMISSION OF THE VIRUS FROM DISEASED TO HEALTHY *AGERATUM* WEED	237
XI.	NUMBER OF WHITE-FLIES AND THE PERIOD OF THEIR FEEDING ON DISEASED SOURCE NECESSARY FOR THE TRANSMISSION OF LEAF-CURL AND THE INCUBATION PERIOD OF THE DISEASE INSIDE THE PLANT	237
XII.	OTHER PLANT HOSTS OF WHITE-FLY	243
XIII.	DISCUSSION AND CONCLUSIONS	244
XIV.	ACKNOWLEDGMENTS	246
XV.	REFERENCES	246

*The scheme is financed by the Imperial Council of Agricultural Research to whom the authors are indebted for the financial aid.

Generally speaking, young transplants and young tillers of earlier transplanted and therefore advanced plants are attacked. Usually the damage is severe in the former and when the transplanting operations become late as much as 50 to 75 per cent. of the plants may be affected. Also plants standing in water are more liable to be attacked than those in waterless lands.

The fly lays reddish elongated tubular eggs about 0·5 mm. long and about 0·125 mm. thick, with rounded ends " on the hairs of the ligules or on the lower surface of the basal parts of leaves and rarely also on their upper surface. The tiny young larvæ creep down between the leaf-sheaths till they reach the growing point of the apical or the side buds. On entering the interior of the buds, they seem to lacerate their tender tissues and feed on their nutritious juices. Whether by actual feeding or continual irrigation, an oval chamber is formed round the maggot in the tissues of the growing point. Further normal apical growth being stopped all the nutrition is directed to the walls of this chamber which elongates like a normal internode (forming the characteristic long gall). By the time the outgrowth begins to be visible, the maggot will generally have turned into a pupa and in about six days will be ready to emerge as a fly. When about to transform, the pupa with the help of the dorsal spines of its abdominal segments wriggles up the hollow tube and boring a hole at the tip with its front spines, partially projects out. The adult now emerges and flies away, leaving the empty pupal skin at the tip of the hollow shoots " (Y. Ramachandra Rao). Each female is capable of laying about 100 eggs. The time occupied from the time of oviposition till the emergence of the fly seems to be about two to three weeks.

It is not known how the fly passes the rest of the year or whether it breeds in any other plant than paddy. In 1917 Rao Sahib Y. Ramachandra Rao published his observations on galls occurring in various grasses in Madras. (*Proc. Asiatic Soc. Bengal, New Series*, Vol. XIII, No. 5, pp. 299-306, 28th December 1917—Reprinted in *Pusa Bull. No. 89, Second Hundred Notes on Indian Insects*). He noticed in October 1916 similar silver shoots as in rice in *Panicum staninum*, an aquatic plant common at Samalkota along canals, in shallow tanks and along water channels in wet lands. The fly reared from this gall was found to be identical with the rice gall fly (*Pachydiplosis oryzæ*). At Coimbatore however this grass did not show any gall formation although the rice gall fly was common there. Similar silver shoots were also observed by him at Samalkota in wild varieties of *Paspalum scrobiculatum* and *Oryza sativa*, but no fly could be reared from them on account of heavy parasitization. The question of alternative foodplants and

behaviour of the fly throughout the year still remains unsolved and obscure.

As regards control we have got the following facts :—

1. In 1915 this pest occurred extensively in the neighbourhood of Ranchi and in Khunti Sub-division of the Ranchi district. Mr. A. C. Dobbs, Deputy Director of Agriculture, in charge of this area, had an opportunity of keeping this area under his observation throughout the season. In the middle of August and early September he reported extensive damage. In the second week of September the writer visited the affected area near Ranchi and found that certain kinds of rice and certain fields newly transplanted were affected to the extent of about 5 to 50 per cent. In November Mr. Dobbs reported as follows :— " The crop at Khunti and here (Ranchi) have made a remarkable recovery owing to a good *hathia* (rain) and it looks as if the effect of the attack is temporary and more or less confined to the shoots attacked. On the return of favourable conditions the plants throw out side shoots and make a more or less complete recovery."

In rice, sugarcane and allied plants whenever a growing point is damaged, further growth is stopped. But if the conditions be favourable the plants always make an attempt to compensate the loss by throwing up side-shoots and tillers. In Bengal, the cultivators apply *Khari nun* (crude sodium sulphate) in fields affected by this disease and they assert that it checks the disease. The explanation seems to be that the growth of the plants is stimulated and recovery takes place owing to the development of tillers and side-shoots.

2. During the outbreak of 1915 in the Ranchi district it was observed that broad-casted paddy sown in April, May or June, and therefore much advanced in growth at the time of the writer's visit in the second week of September, was practically immune (their young side-shoots being affected to a small extent) compared with the late-transplanted young seedlings. Transplantation was still going on at the time. Therefore it seems that carrying out of the transplanting operations early in the season would be a preventive, but this is entirely dependent upon the prevalence or otherwise of favourable climatic conditions.

3. There is a minute black parasitic wasp (*Platygaster oryzæ*) which seems to keep the pest in check. In some years however and in some localities owing to unknown reasons the number of the parasites decreases, resulting in a corresponding increase in the number of the fly with more damage to paddy as a consequence. At Ranchi in the second week of September 1915 only about one per cent. of the maggots was observed to be parasitized. In Madras in 1913 and again in 1914 (years of normal slight infestation) the maggots were parasitized to such an

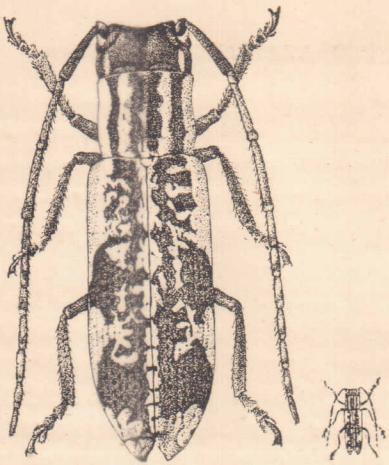


Fig. 1.—*Lychrosis zebrinus.* Beetle (Magnined ; the smaller figure shows the natural size).

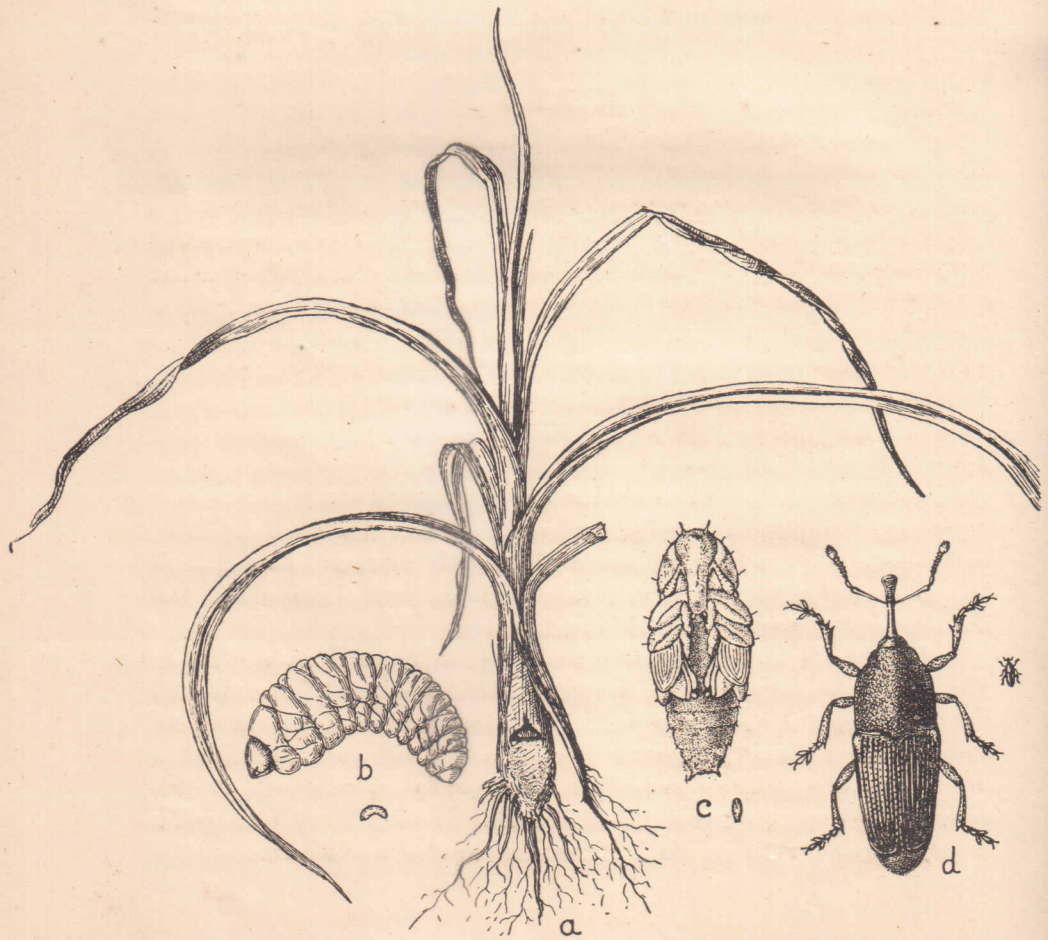


Fig. 2.—Weevil Borer (C.S. 2044) ; *a*, attacked *Mootha* plant ; *b*, larva ; *c*, pupa ; *d*, beetle (*b*,*c*,*d*, magnified, the smaller figures showing the natural sizes).

enormous extent that it was difficult to rear out adult flies. About 20 to 30 grubs of this parasite occur in the body of a single maggot. They devour the contents of the body of the maggot by the time the latter is full grown and pupate in brownish cocoons formed in a mass inside the skin of their host. This cocoon mass is observed on splitting open the hollow gall.

4. The adult flies are attracted to bright powerful lights. No flies were attracted at Ranchi to a light trap improvised with an ordinary hurricane lantern and new shining pieces of tin used as reflectors. In Madras, on 25th October 1915, 27 flies (mostly females) were recorded to have come to the Aladdin Incandescant Lamp and between 28th October and 2nd November 1915, 96 females and 11 males were attracted to what is called a P. W. D. lamp.

Taking the above facts into consideration it is clear that the best remedy for the cultivator to adopt is to try to improve the conditions by the application of manures, irrigation when necessary and other means, so as to bring about a healthy and vigorous growth of side shoots and tillers.

Lychrosis zebrinus, Fb.

(Plate XVIII, fig. 1.)

Foodplant—*Batri* (*Saccharum spontaneum batri*).

Hibernating larvæ were collected in February 1920. One pupated in May and emerged on 16th May 1920. The larva resembles that of the Lamiad borer (C. S. 1814) described in the first paper. (*Proc. Third Entl. Meeting*, p. 372).

The weevil borer (C. S. 1397 and 2044).

(Plate XVIII, fig. 2.)

Foodplant—*Mootha* (*Cyperus rotundus*).

It has been referred to in the first paper. (*Proc. Third Entl. Meeting*, p. 373). The remarks made under *Bactra truculenta* at page 126 of this volume regarding the foodplant should be seen. This insect has not been found in any other food plant.

Eggs are apparently deposited inside the stem near the root-stock. The grubs are found right at the root of the stem at its junction with the root-stock. They do not work up the stem but gnaw a large cavity at this place thus cutting across the base of almost all the leaves of the inner whorls which droop, turn yellow from their spices and ultimately wither. The cavity the grubs gnaw is filled with black excreta. Sometimes the grubs are observed to bore into the root-stocks.

Pupation takes place inside the stem or rootstock and rarely in the ground. The periods of the different stages are not definitely known. The life-cycle seems to be completed in about three to four weeks.

The fullgrown grub is about 4 mm. long and about 1·5 mm. across the thoracic region from which the body tapers gradually both ways. The head is much smaller than the prothorax, pale yellow in colour and glossy. The body is subcylindrical in shape being slightly compressed in the dorsoventral plane. The skin is wrinkled and the segments are hardly distinguishable. The colour of the body is pale yellow with a brownish tinge which disappears before pupation. On each side a white tracheal tube is visible under the skin. The pupa is about 3 mm. long and of the ordinary Curculionid type. It is yellowish white in colour. The weevil is black.

Sesamia inferens.

To the foodplants Lemon grass is added.

C. S. 1666.

Katra (*Andropogon squarrosus*) is added to the foodplants.

Heterographis sp. (C. S. 1700).

The Phycitid borer of tender maize cob referred to at page 378 of the first paper is *Heterographis* sp. It has not been observed to occur again.

The Phycitid Borer. (C. S. 1837 and 2060.)

(Plate XIX, fig. 1.)

Foodplants—*Marua* (*Eleusine coracana*).
Rice (*Oryza sativa*).

This borer has been referred to in the first paper (*Proc. Third Entl. Meeting*, p. 378) as occurring in *Eleusine coracana*, but it has since been observed in rice stems also. It however never appeared in large numbers and from its seasonal history and its habits it appears that it will most probably never rise to the rank of a major pest. The caterpillars have been observed to rest in the Insectary from September to the end of June and they have been collected from the fields in July and August, moths being reared in the Insectary between 8th August and 6th September. Out of a lot of seven caterpillars collected in the latter half of August three developed into moths between 28th August and 6th September and the others rested as stated above, till the end of June

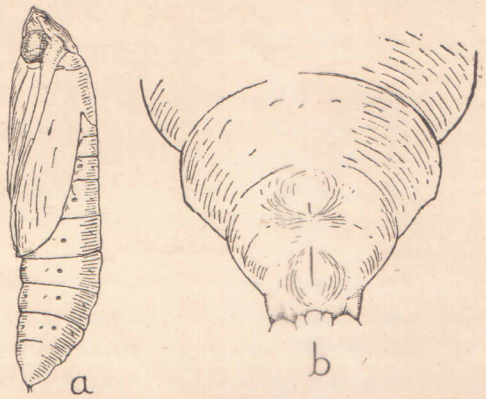


Fig. 1.—Phycitid Borer (C.S. 2060); *a*, pupa (×7); *b*, ventral view of hinder end of pupa, more highly magnified.

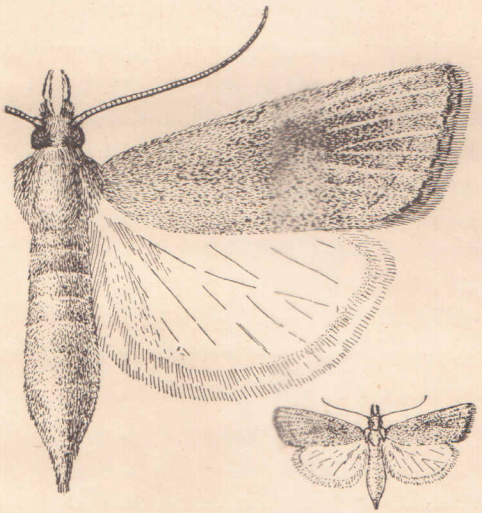


Fig. 2.—*Diatræa auricilia* (magnified; the smaller figure shows the natural size).

next year. They did not mind the dry conditions prevalent during the winter and the hot weather. Therefore the insect appears to have only one generation in the year, some probably having two.

The caterpillars are observed to enter the stem near the base through a hole gnawed on the side and then bore down towards the root. The result of course is dead heart. When full-grown the larva usually leaves the stem and pupates in a tubelike silken cocoon formed under the earth and among the roots of the plants in the clump. The cocoon goes down vertically or obliquely to a depth of about three-fourths of an inch, its mouth remaining open at the surface of the soil so as to enable the moth to emerge without difficulty. The pupa lies at the closed bottom end with its head turned towards the opening. The pupal period is about nine days.

The caterpillars cannot attack paddy in submerged lands. They have been observed to occur only in dry land paddy and the other food-plant observed, *viz.*, *marua* (*Eleusine coracana*) is also a dry land crop. Their habit of feeding and pupating underground precludes their occurrence in submerged crops.

A full-grown larva measures about 12 mm. in length and is about 2 mm. across the mesothorax which is the broadest part from which the body tapers gradually though slightly towards both extremities. The shape is cylindrical and the segments clearly distinguished. The head is yellow, hardly glossy, has brown mouthparts and is partly retractile into the prothorax. The body is uniform creamy white without any warts. The meso- and meta-thoracic segments are divided into three subsegments of which the middle one is the largest. The eight abdominal segments are divided into two subsegments of which the anterior one is larger than the posterior one. The hairs are thin, whitish. The spiracles are round, yellowish with a narrow brown rim. The hooklets on abdominal prolegs are arranged in an elongated oval outline, the inner end of this outline being narrower than the outer end. There are five pairs of short but equally developed prolegs.

The pupa is about 8 mm. long and about 2 mm. thick across the thorax, cylindrical in shape, tapering at the head end as well as hindwards. The head end is somewhat protruded, the protruded part being compressed in the lateral plane and having a raised ridge in the middorsal as well as in the midventral region. The abdominal segments are devoid of spines or ridges or roughnesses. The spiracles are broadly oval, rather large, brown spots under which a tracheal tube is visible in the abdominal region. The hind end has six pyramid-shaped papillæ arranged in a straight row in the lateral plane. The two outside papillæ are large and the others diminish in size inwards. Each of them is

tipped with a short hair. The colour is creamy white, the protuberance on the head and the anal papillæ turning brownish as the pupa matures.

Saluria inficita, Wlk.

Foodplant—*Ragi or Marua* (*Eleusine coracana*).

This borer is mentioned in *South Indian Insects*, pp. 427-428, where an illustration is given. It was observed as a minor pest on the Central Farm at Coimbatore in August and September in 1908, 1909 and 1913. It has not so far been observed in North India. It is allied to the previous species.

The following note on the lifehistory appears in the above-mentioned publication : " The larva is moderately stoutly built, the prothoracic segment is large, the next two segments short but projecting ; in colour it is pure creamy white, the head yellowish tinged with blackish around the mouthparts ; there are a few short white inconspicuous hairs on all segments. It bores into the stem of the foodplant low down at about or just above ground-level and pupates in the stem or emerges and pupates in a small chamber excavated in the soil. The female moths are attracted to light at night."

Scirpophaga xanthogastrella.

Ikri (*Saccharum fuscum*) is to be added to the list of foodplants.

Procometis trochala, Meyr. (Plate XVII.)

Katra (*Andropogon squarrosus*) is to be added to the list of foodplants. The caterpillars webbed up the bases of the plants in the stool at the surface of the soil and nibbled the surfaces.

Raphimetopus (*Anerastia*) *ablutella* has not been observed to occur during the last two years.

Chilo simplex.

Add to foodplants *Coix lachryma-jobi* var. *aquatica*.

The larva was once found boring *Chichera* (*Luffa* sp.) fruit at Pusa in July.

In Burma I did not come across *Chilo simplex* during my search in the cold weather of 1920-21.

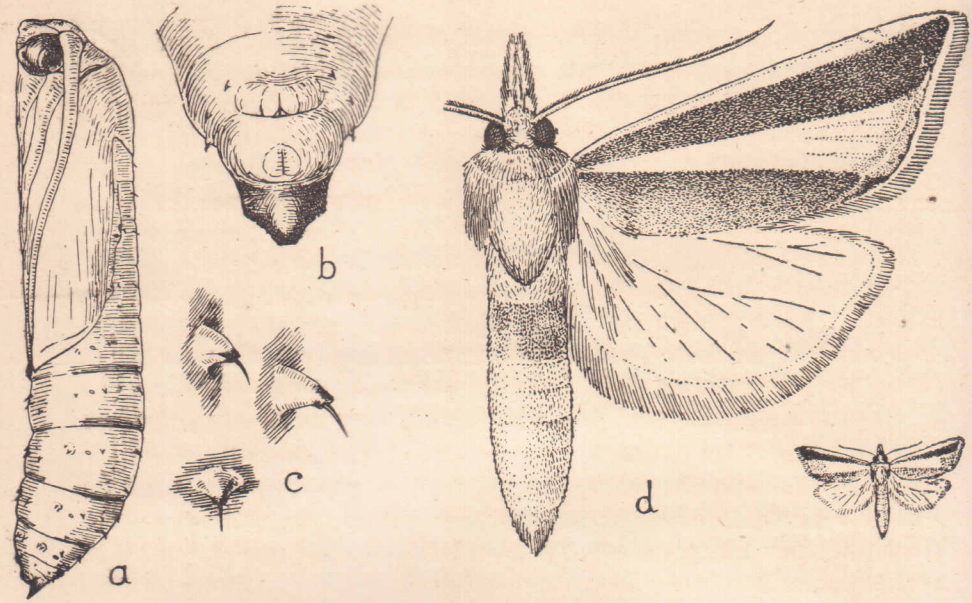


Fig. 1.—*a*, Pupa (×5); *b*, ventral view of hinder end of pupa, more highly magnified; *c*, details of spines on pupa; *d*, moth, natural size and magnified.

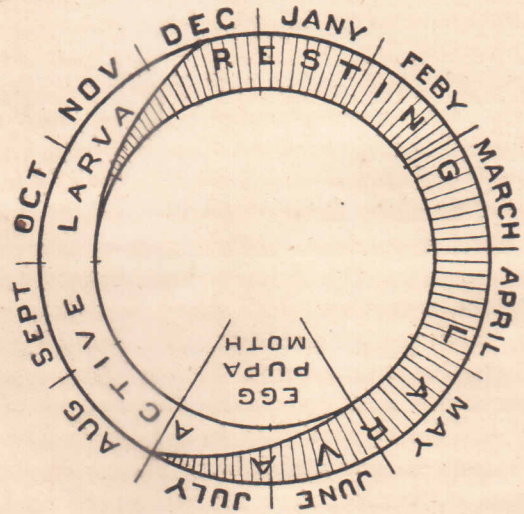


Fig. 2.—Annual life-cycle at Pusa.

Chilo torrentellus.

Diatraea venosata, Wlk.

A notable observation with regard to this borer is that it was found in December 1919 to occur as a regular pest of sugarcane at Cuttack where no *juar* (*Andropogon sorghum*) is grown and hardly any *Saccharum spontaneum* occurs. At Pusa, where there are extensive tracts under *juar* and *S. spontaneum*, *D. venosata* occurs very commonly in *S. spontaneum* and *juar* but very rarely in sugarcane.

Chilo torrentellus.

(Plate XX.)

Foodplant—*Rarhi* and *Batri* (*Saccharum spontaneum*).

It has been referred to as a Pyralid Borer (Pl. 64, fig. 1) in the first paper (*Proc. Third Entl. Meeting*, p. 393). The stems are bored in their central part and converted into hollow tubes. When the larva bores near the top the heart shoot dies and dries. Otherwise there is hardly any prominent external symptom. The caterpillars are found in very large numbers. They may be looked for in thin reedlike varieties of sugarcane, although none has been observed in this plant yet.

The young and full-grown caterpillars resemble one another in appearance. The full-grown larva is about 35 mm. long when fully stretched. The mesothorax is thicker than other segments and measures about 3·5 mm. across and from this segment the body tapers both ways slightly and gradually. The shape is cylindrical but looks slightly compressed in the dorsoventral plane. The head is yellow, glossy, with the buccal region and appendages dark brown. The prothoracic shield is not prominent. The thoracic segments have a tinge of the same colour as the head. The segments of the body are not very prominently distinguished. The skin of the whole body has a shiny appearance and is naked, the primary hairs being minute and black. The spiracles are elongated oval, wholly light-brown with a narrow dark rim. Along the spiracles a tracheal tube is faintly visible under the skin. The hooklets on the five pairs of short but equally developed prolegs form complete circles. Before pupation the larva gnaws a hole on the side of the stem, the mouth of the hole being kept closed by a thin membrane of the bark. Pupation takes place inside the bored stem near this hole in a sort of a cocoon formed with chewed particles spun up with silk. The pupa is about 14 mm. long by about 2·75 mm. thick, cylindrical. The head end is somewhat protruded forwards. The dorsal part of the hind end is protruded into a thick broad wedge-shaped process which possesses no spines of any kind. The 4th to 9th abdo-

I. Introduction

In the second part of our investigations on tobacco leaf-curl [Pruthi and Samuel, 1937] we stated that sann-hemp at Pusa also suffers from leaf-curl and described some transmission experiments performed during 1935 which showed that white-fly, *Bemisia gossypiperda* M. & L., could transmit the disease from sann-hemp to healthy tobacco. During the last two tobacco seasons (1936-37 and 1937-38) we have performed a large number of transmission experiments with white-fly to confirm our previous conclusions referred to above and to ascertain if this insect could also transmit the disease from tobacco back to healthy sann-hemp and from tobacco to tobacco and sann-hemp to sann-hemp. Furthermore, during the course of our work we have observed that *Ageratum conyzoides*, which is a very common weed at Pusa and which also suffers from a leaf-curl disease, serves as a food plant for the white-fly. We have experimented with this weed to determine if this plant, like sann-hemp, is an alternate host of the tobacco leaf-curl virus. Several large series of experiments on the lines indicated above have been performed at different times of the year on tobacco and other hosts of different ages to determine the season when the white-fly is most viruliferous and the ages of various hosts when they most readily get infected and develop the disease. Some very interesting results have been obtained which are reported in the present paper.

II. Technique, material, etc.

In our previous investigations [Pruthi and Samuel, 1937] we used cellophane tubes for encasing the white-fly on the diseased and healthy plants for feeding. As whole leaves had to be enclosed inside the tubes, the latter had necessarily to be very large. It was noticed that the white-flies generally remained in the corners and folds of the crumpled portions of the tubes instead of sitting and feeding on the enclosed leaves. As the longevity of the white-fly in captivity is rather short, it seemed probable that the encased individuals did not feed on the diseased plants at all or, if they did so, they did not feed for sufficient time on the healthy plants on which they were transferred. Furthermore, cellophane has the very serious draw-back in that with slight changes in weather conditions it readily expands and shrinks and consequently becomes very brittle. Therefore in the experiments carried out during the last two years and reported in the following pages, the technique of feeding the white-fly was considerably modified. Instead of a large cellophane tube for encasing an entire leaf, a small glass tube (1 in. $\times \frac{1}{2}$ in.) containing the individuals was fixed on a portion of the leaf by means of a light wire spring which clasped the tube and leaf together as shown in Fig. 1. To avoid injury to the leaf, the end of the spring which rested on it was flattened into a disc and was separated from the leaf surface by means of a felt piece. The white-fly generally feeds on the lower surface of the leaf, therefore, the tubes were also fixed on that surface. This as well as the fact that the white-fly always flies up when put in a tube ensured the settling of the individuals on the portion of the leaf covering the open end of the tube.

minal segments have spines in places corresponding to the primary tubercles of the larva. The spines are broad and have a needle-like short thin process arising slightly below the tip. The colour is yellow. The spiny pupa is liable to be confused with that of C. S. 1835 (Plate XX, fig 1*a*) but can be distinguished by looking at the hind end.

The moth is quite different from that of all the other borers, the forewings being white with a broad blackish longitudinal marking in the middle.

The seasonal history has been graphically shown in the chart (Plate XX, fig. 2). The moths appear in June, July and August, when eggs are laid. The egg has not been observed. Young caterpillars occur about this time and feed till about November when hibernation commences inside the bored stems. After hibernation and partial aestivation, pupation commences in May and moths appear in June. In the Insectary caterpillars have been observed to rest till about the middle of October and then die. This prolonged rest may indicate that probably some larvæ do not pupate till the second year. Or it might be due to Insectary conditions.

Hypsotropa tenuinervella. (C. S. 1920 and 2016.)

(Plate XXI.)

Foodplant—*Katra* (*Andropogon squarrosus*).

The seasonal history is graphically shown on Plate XXI, fig. 2. The larvæ hibernate from about October to about March and are not affected by dry conditions. In the Insectary moths were observed to emerge up to 9th October 1919 before the winter and on the 14th March 1920 after the winter.

The caterpillars are true borers. They are of three different colours. Some are red, some are cream coloured and some pale yellow, although morphologically they are the same. A full-grown caterpillar is about 15 mm. when stretched and about 2·5 mm. thick. The head is compressed in the dorso-ventral plane, brown and glossy. The prothoracic shield is not very distinct, glossy pale brownish-yellow. The segments of the body are divided into two subsegments, the anterior subsegment being large and the posterior small. The hairs are thin, brownish. The spiracles are broadly oval, not exactly round, pale yellow with a thin brown rim. The five pairs of prolegs are equally developed, the hooklets on them being in elongated oval outline.

All turn pale yellow before pupation.

PLATE XXI

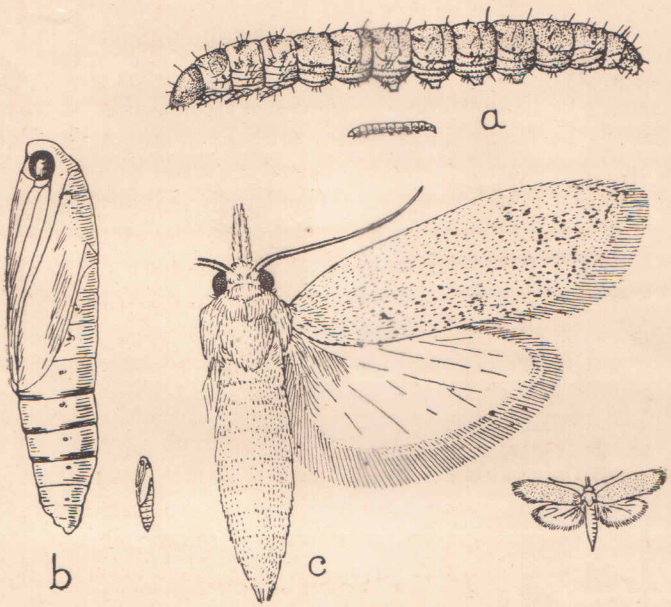


Fig. 1.—*a*, larva ; *b*, pupa ; *c*, moth ; all ×5 and natural sizes.

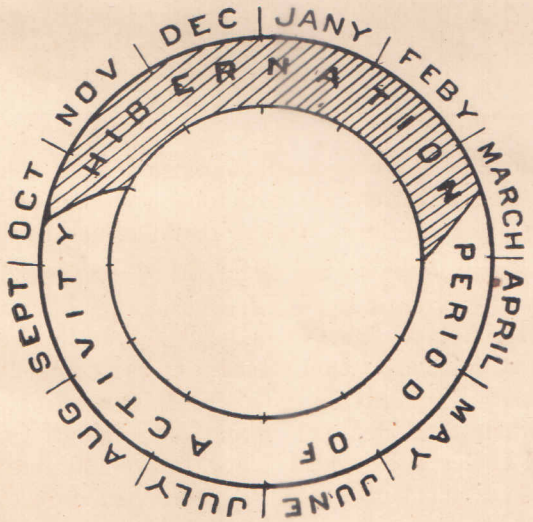


Fig. 2.—Annual life-cycle at Pusa.

Hypsotropa tenuinervella.

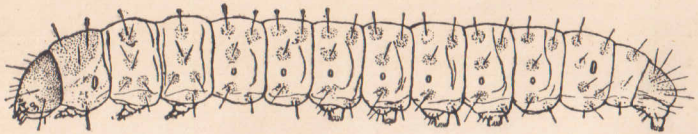


Fig. 1.—Larva (magnified).

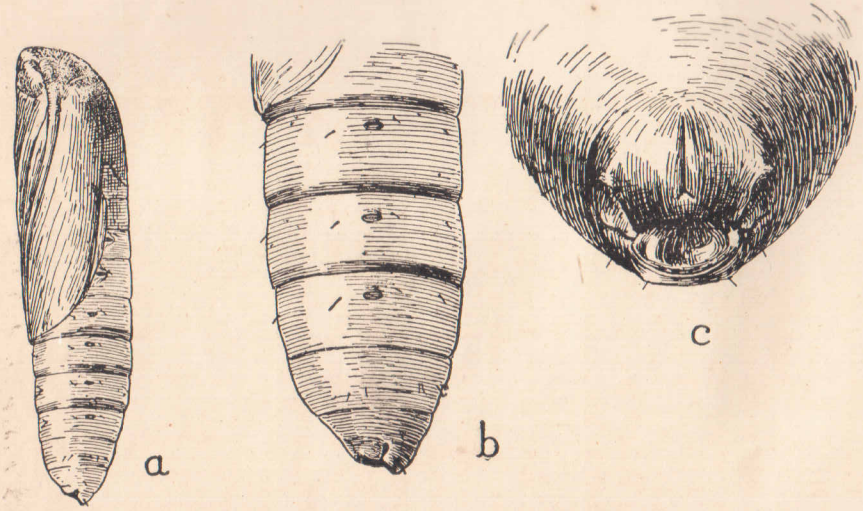


Fig. 2.—*a*, pupa (magnified); *b*, hinder-end of pupa, more highly magnified; *c*, ventral view of hinder-end of pupa, still more highly magnified.

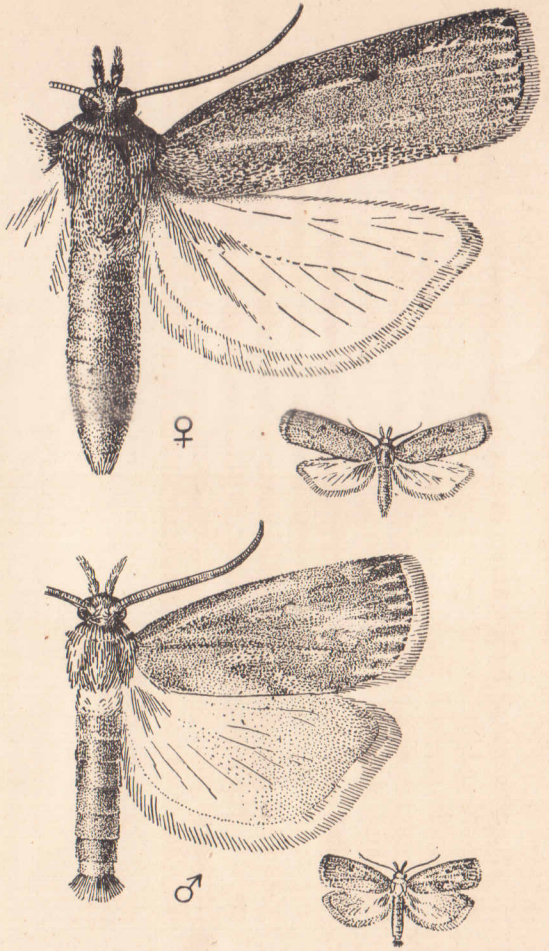


Fig. 3.—Moths (female above and male below) natural sizes and magnified (×4).

Crambus corticellus.

PLATE XXII

Pupation takes inside bored stems in silken cocoons with pellets of excreta and bits of leaf webbed on its surface. One end of the cocoon communicates with the hole of exit the larva prepares for the future moth on the side of the stem, the mouth of the hole being closed with the thin epidermal layer of the leaf sheath.

Pupa is about 11 mm. long by about 2·5 mm. across the thoracic region which is slightly compressed in the dorsoventral plane. The abdominal region is cylindrical and tapering hindwards almost to a point. The head end is tapering, with an indistinct longitudinal ridge on its ventral side. The spiracles are elongated oval, brown-rimmed. The colour is yellow with a brownish tinge at the anterior part.

Crambus corticellus, Hmpsn.

(Plate XXII.)

Foodplant—*Scirpus corymbosus*.

This insect was observed to bore the sedge named above at Nagpur by Mr. J. L. Khare. The caterpillars were collected in January, April and May. There are specimens in the Pusa collection taken at Pusa almost throughout the year. Apparently the insect is active throughout the year.

A larva, about half-grown and preserved in spirit, has a glossy brown head. The prothoracic shield is of the same colour as but paler than the head. Warts on the segments large, roundish and of the same colour as the prothoracic shield. The general colour of the body is pale yellow. The prothoracic and the eighth abdominal pairs of spiracles are much larger than the others. All the spiracles elongated oval, a brown rim enclosing a clear space. The hooklets on prolegs are arranged in a complete circle.

Pupa, about 14 mm. long and about 3 mm. thick, cylindrical and brownish yellow in colour. The abdominal segments possess no spines or roughnesses. The dorsal part of the hind end is protruded to some extent and the protruded part has a rounded margin, is flat on the ventral and convex on the dorsal side and possesses no spines of any kind.

Bactra truculenta, Meyr.

(Plate XXIII, fig. 1.)

Foodplant—*Mootha* (*Cyperus rotundus*).

This insect has been referred to in the first paper (*Proc. Third Entl. Meeting*, p. 394). It has not been observed to occur in any other

plant. *Mootha* is a troublesome weed in many parts of the country and it takes several years of careful uprooting along with the root-stocks to eradicate it from lands newly brought under cultivation. Although it serves partly as food for cattle, there are some varieties of it which are not liked by cattle. It grows very profusely and luxuriantly and the influence of this borer aided by the weevil borer referred to at page 119 of this volume seems to be very small as a check.

In the neighbourhood of Pusa this insect is observed to be active throughout the year. The caterpillars do not bore down from the top but effect their entrance into the centre of the leaf-bundle or into the stem in advanced plants, through the lower leaf-sheaths and tunnel up and down the central region but never enter the root-stock. The result of course is dead-heart in young plants but in the fully developed stem the effect is hardly apparent externally. Pupation takes place inside the stem of the affected plants in an elongated silken cocoon formed lining either the tunnel or the outer leaf-sheaths, the moth emerging after about five days. Ordinarily the life-cycle seems to be completed within about three weeks.

Full-grown larvæ measure about 12 to 15 mm. in length and about 1·5 mm. in thickness across the anterior part of the body which tapers gradually and slightly hindwards. They have a slender, longish and dorsoventrally compressed appearance. The head is slightly smaller than the prothorax which has a distinct shield of the same colour as the head. Spiracles are round, a narrow brown or black rim enclosing a clear space. Running along and connecting the spiracles a tracheal tube is more or less visible under the skin. There are five pairs of equally developed prolegs with hooklets arranged in a circle. In coloration the larvæ vary a good deal, the following three types occurring commonly :—(1) Body pale yellow with the mesothorax, metathorax and to a less extent the first two abdominal segments purplish and head brownish yellow. (2) Body green with the mesothorax, metathorax and the first two abdominal segments smoky or dusky and head pale yellow with a greenish tinge. (3) Body uniform pale yellow with dark grey or black head. Green larvæ are the commonest of all.

The pupa is about 5 to 7 mm. long, cylindrical, tapering slightly towards hind end. Each of the third to eighth abdominal segments has two transverse rows of spines on the dorsal side, the row at the anterior part consisting of straight posteriorly directed spines and that at the posterior part of very small spines. The ninth abdominal segment has a single row of large spines the tips of all or some of which are curved up anteriorly. The hind end is rounded and has a pair of small pyramidal papillæ surrounded with hairs. The colour of the

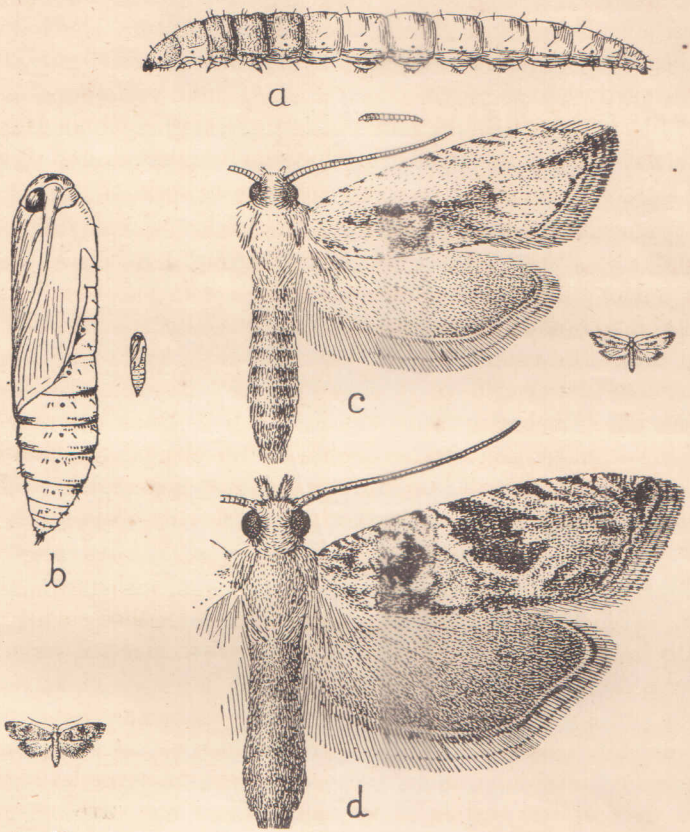


Fig. 1.—*Bactra truculenta ; a*, larva ; *b*, pupa ; *c*, *d*, moths, all natural size and magnified (×8).

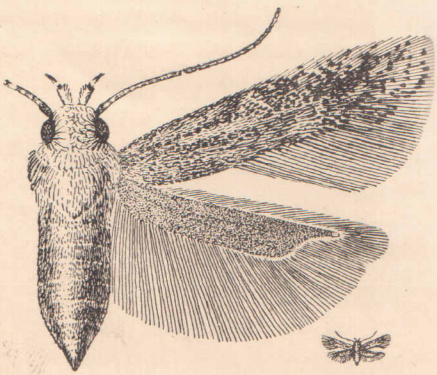


Fig. 2.—*Ephysteris chersœa*, Moth, natural size and magnified (×11).

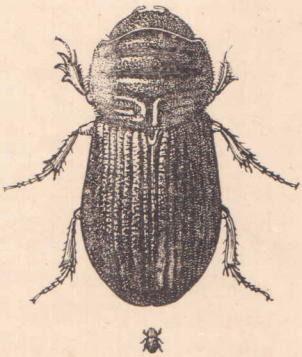


Fig. 3.—*Rhyssemus germanus*, natural size and magnified (×13).

pupæ too varies. The pupæ of the green larvæ are green with the head, thorax and wing regions brownish yellow. Other pupæ are pale brownish yellow turning in the end grey brown with the wing regions black.

The moths too are variable in colour. Some are grey or yellowish with longitudinal dark marking along the middle of the forewing. Others have the entire surface of the forewing covered with blackish patches.

Ephysteris chersœa, Meyr. (C. S. 2046).

(Plate XXIII, fig. 2.)

Food plants—Rice (*Oryza sativa*), Pusa.
China (*Panicum miliaceum*), Pusa.
Juar (*Andropogon sorghum*) stubbles, Coimbatore.

The caterpillars occurred at Pusa in small numbers. They were boring *China* stems in June and rice stems in July. At Coimbatore they were reared from *juar* stubbles. Moths were collected by Mr. T. Bainbrigge Fletcher at Abbottabad in June and they were also collected at Purnea. This insect has not yet been observed to occur in sufficiently large numbers to justify its inclusion in the list of pests.

The full-grown larva is about 6 mm. long and cylindrical in shape. The head is reddish brown. The prothorax has a blackish shield divided longitudinally in the middle. The general colour of the body is pale yellow with a broad dark grey band on each segment. Five pairs of equally developed prolegs are present.

The pupa is about 4 mm. long, cylindrical in shape and tapering hindwards. The hind end is rounded and has a few short thin circinate hairs at its dorsal part. The colour is yellow brown. In one case the larva left the stem and pupated underground.

Oryctes rhinoceros.

This beetle lays eggs in rotting masses of leaves, straw or grass, rotting stems of coconut and other palms, moist rotting wood or sawdust and in manure pits. The grubs feed on the decomposing vegetable matter. The adult beetles however fly at night and bore into soft crowns of Coconut, Date, Toddy and other palms (except, so far as known, Betel Nut palms). As they occur in large numbers they bring about the death of many trees, thus constituting a serious pest especially of coconut palms. They are also known to bore American Aloes and

occasionally sugarcane. The photograph, reproduced as fig. 69 of *South Indian Insects*, records its occurrence on sugarcane at Coimbatore in October 1913 and shows the characteristic chewing of the beetle. They may occasionally be expected on thick varieties of sugarcane but will probably never prove a regular pest of this crop. [This insect has, however, occurred in the Malay States as a pest of sugarcane. T. B. F.]

So far as is known this insect passes through a single generation in the year. The egg and pupal stages are short, lasting only for about one-and-a-half to two weeks, the rest of the long cycle being passed in larval state. Adult beetles have been reported from different localities from about June to December or even January. Beetles emerged in the Pusa Insectary from grubs collected from outside between May and August. May to August probably represents the time of emergence of the adults which seem to be able to live for long periods under favourable conditions and are therefore reported to occur even in December or January. Variations apparently occur in the lifehistory according to varying conditions of different localities. It is not known whether there is a definite period of oviposition or whether eggs are deposited throughout the period the adults live.

Apogonia proxima, Waterh.

A pupa and many adults were collected at Pusa among *Saccharum spontaneum* roots in September. The pupa was collected on the 5th September and the beetle emerged from it on the 10th September.

In July, that is, soon after the commencement of the rains, large numbers of this beetle are observed at Pusa to come out at dusk and eat tender leaves of *Ficus religiosa*, *Vitis trifolia*, *Capparis* sp., and other plants. They sit in clusters or rather hang on leaves. Males come and mate while females continue eating.

A number of them were collected in July 1914. In confinement they ate leaves and laid eggs freely, which hatched in a week. The eggs are about 1·5 mm. in diameter, round with a smooth surface and creamy white in colour which turns brownish before hatching when the powerful brown mandibles of the embryo are visible through the shell. Attempts at rearing the larvæ failed.

It appears that the beetle passes through only one generation in the course of the year. Apparently the winter and early summer are passed in larval state.

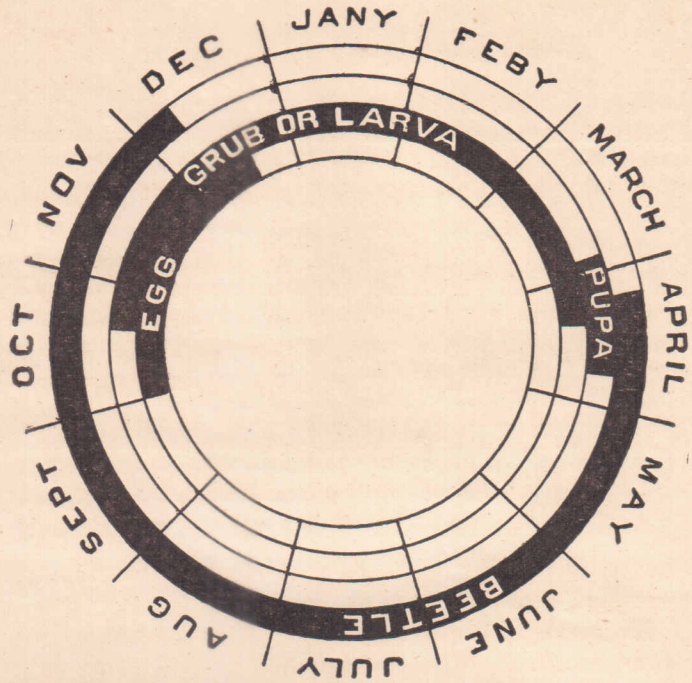


Fig. 1.—*Allissonotum impressicolle.* **Annual life-cycle as observed at Pusa. The black portions indicate the periods of the year when the different stages are found.**

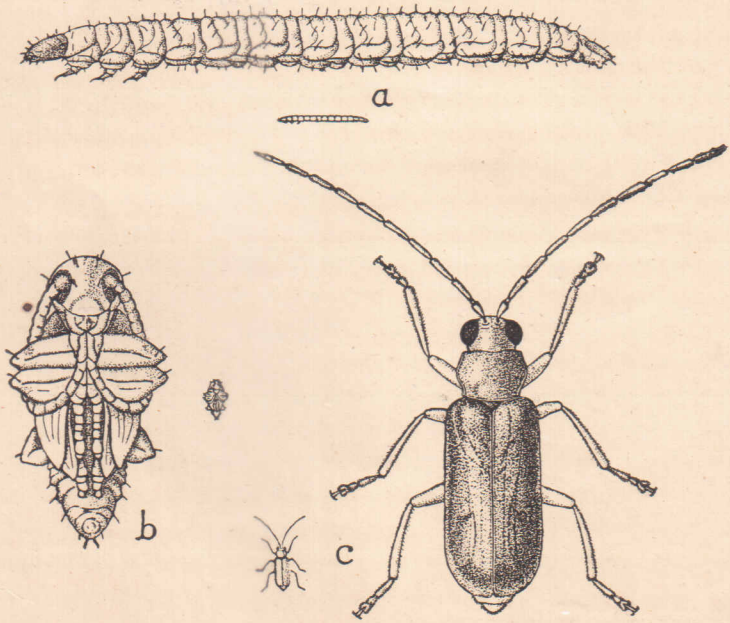


Fig. 2.—C. S. 1640 ; *a*, **larva ;** *b*, **pupa ;** *c*, **beetle ; all natural sizes and magnified.**

Rhyssemus germanus (C. S. 1204).

(Plate XXIII, fig. 3.)

Foodplant—Larvæ found among *mootha* (*Cyperus rotundus*) and indigo roots.

This is a small beetle but their small size is more than made up for by the numbers in which they occur. The seasonal history is not understood quite well yet. Probably there are several generations in the hot weather and in the rains, the cold weather being passed in hibernation. In the hot weather from about March to June enormous numbers of the adult beetle fly about in the air at dusk.

Alissonotum impressicolle.

(Plate XXIV, fig. 1.)

The occurrence of this beetle on sugarcane in the Kamrup Farm has been referred to above when dealing with the external agents of damage. The beetles collected in the second week of May 1919 were brought down to Pusa. When collected they were kept with moist earth in a perforated zinc cage and pieces of thick cane stems were supplied as food. They ate voraciously, boring into the pieces of cane. On arrival at the Pusa Insectary, 216 beetles were distributed on 30th May in two glass jars, 108 in each, the jars being filled with moist earth under which sugarcane setts and shoots were placed as food. Between 3rd June and 1st August, 21 beetles were observed to come up to the surface of the earth one or two at a time and at intervals of several days and die there. This was probably due to overcrowding. Otherwise they were resting and did not feed. On 20th October 1919 the jars were searched ; 54 beetles were alive and 68 eggs found laid in the earth. Of these 68 eggs :—

2	hatched	22nd October.
3	„	24th „
2	„	30th „
2	„	2nd November.
2	„	3rd „
2	„	4th „
4	„	5th „
2	„	7th „

20th-21st October.—35 eggs laid :

1	hatched	31st October	11-20 days ; earlier dates probably not correct as some eggs laid previously might have been left over
2	„	2nd November	
4	„	4th „	
3	„	5th „	
1	„	10th „	
		rest spoilt	

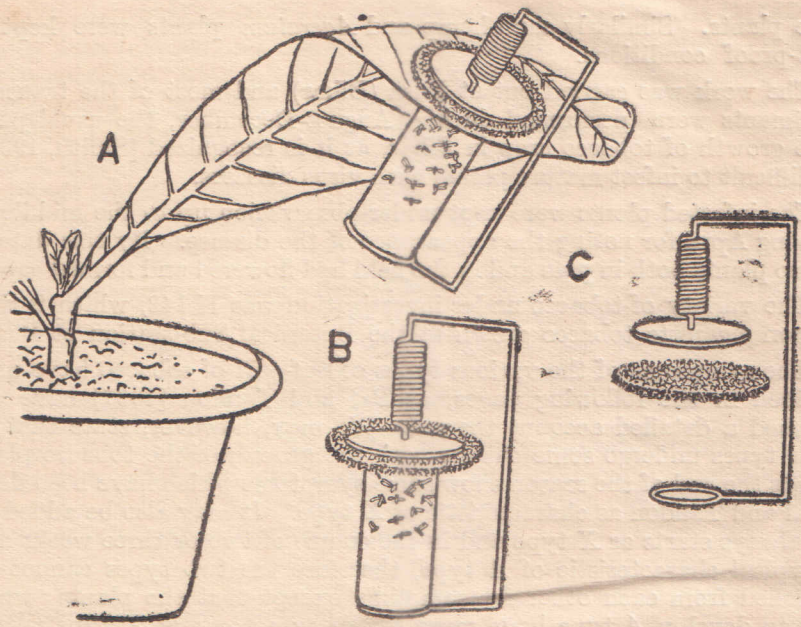


FIG. 1. Diagrammatic illustration of the technique of feeding white-flies on tobacco leaf—*A*. The whole mechanism *in situ*; *B*. The spring and the tube containing the individuals; *C*. The spring showing the felt piece separated from the disc.

The period for which the white-flies were kept on the diseased plants before their transfer to healthy hosts is referred to as the 'feeding period' in the following pages. This, however, is not a very accurate term as the individuals did not necessarily feed for all the time when encased on the leaves After the individuals had been kept on diseased leaves for a definite period. they were transferred to healthy plants on which they were allowed to remain till they died. This was done to ensure their feeding on these plants for the maximum possible period as the percentage infection is known to increase with increased feeding time of the vector on the healthy plant. No record was kept of the period for which the white-flies lived on healthy plants. The total longevity of the white-fly while encased on diseased and healthy, plants varied between three and seven days during August-December. When kept on diseased leaves throughout its life, it did not live for more than about four days. If kept on healthy plants throughout, it remained alive for six to ten days. These observations do not support the statement of Smith [1931] that an infective insect does not present any visible variation from a normal individual.

Tobacco seedlings meant for infection purposes and the controls were raised under insect-proof conditions and were transplanted in pots containing sterilized soil which were kept covered with muslin bags throughout the life

21st-23rd October.—16 eggs laid :

7 hatched	7th November	16-20 days ; rest spoilt.
1 „	8th „	
1 „	11th „	

23rd-24th October.—9 eggs—45 beetles alive : 8 A.M.-8 A.M. :

1 hatched	7th November	15-19 days ; rest spoilt.
1 „	8th „	
2 „	11th „	

24th 8 A.M.-25th October 8 A.M.—8 eggs :

1 hatched	8th November	15-17 days.
1 „	10th „	

1 egg apparently unspoilt yet 6th January 1920. Spoilt 13th January 1920.

25th 8 A.M.-26th October 8 A. M.—10 eggs :

1 hatched . . . . . 11th November 17 days.

1 egg remained apparently unspoilt till 26th December, when it got mouldy.

26th 8 A.M.-27th October 8 A.M.—5 eggs—43 beetles alive :

1 hatched . . . . . 15th November 20 days.

1 egg remained apparently unspoilt till 7th January 1920. Spoilt 27th January 1920.

27th-30th October.—23 eggs—41 beetles alive :

1 hatched	14th November	18-19 days ; rest spoilt.
1 „	15th „	

30th October-2nd November.—26 eggs—33 beetles alive :

1 hatched	17th November	Maximum 20 days, rest spoilt.
2 „	19th „	
1 „	20th „	
1 „	21st „	
2 „	22nd „	

2nd-4th November.—21 eggs—32 beetles alive :

1 hatched . . . . . 21st November.

2 eggs apparently unspoilt 7th January 1920. 1 spoilt 3rd February. 1 spoilt 8th February.

4th-5th November.—10 eggs—30 beetles alive :

1 hatched . . . . . 23rd November. Maximum 18 days. Rest spoilt.

5th-6th November.—6 eggs—29 beetles alive :

2 hatched . . . . . 23rd November. (18 days) rest spoilt.

6th-10th November.—10 eggs—26 beetles alive :

1 hatched . . . . . 26th November.

10th-12th November—22 eggs—26 beetles alive :

1 hatched	27th November.
1 „	29th „

12th-14th November—20 eggs—25 beetles alive :

1 hatched	3rd December	1 egg remained in apparently unspoilt condition till 26th December.
1 „	4th „	
1 „	7th „	

14th-17th November—12 eggs—19 beetles alive : all spoilt.
17th-20th November—8 eggs—12 beetles alive :
1 hatched . . . . . 12th December.
1 egg remained in apparently unspoilt condition till 30th December 1919.

20th-23rd November—7 eggs—9 beetles alive :
1 hatched . . . . . 17th December.
23rd-26th November—1 egg—4 beetles alive :
It remained in apparently unspoilt condition till 4th January.

1st December—No egg—4 beetles alive.
10th December—No egg—1 beetle alive.
14th December—No egg—all the beetles dead.

Twenty-seven grubs, which hatched between 22nd October and 5th November 1919, were placed in one bell-jar with growing maize. On 15th March 1920, only one half-grown was in this jar.

Thirtyone grubs, hatched between 7th November and 12th December, were placed in another jar. On 15th March 1920 eight grubs were living in this jar. One was partly eaten apparently by the other grubs.

31st March 1920—2 pupated.
1 emerged on 10th April
1 ,, ,, 11th ,,

One more found to have pupated on 11th April 1920. It emerged on 21st April.

The grubs hardly did any damage to sugarcane and fed mostly on the manure.

The eggs are white and have a smooth membranous shell. They vary in size. The smallest ones are oval or almost oval in shape measuring about 1·75 mm. in length and about 1·5 mm. the other way. The larger ones are almost round and the largest of them is about 2·5 mm. in diameter. The eggs increase in size with age.

20th October 1919—3 eggs, 1¾ mm....1½ mm., were kept separately.
27th October 1919—One was spoilt—2 almost round about 2 mm. in diameter.

All eggs do not attain the same size. They vary from about 2 to 2·5 mm. in diameter. The newly-hatched grubs also vary in size, varying in length from about 3·5 to 5 mm. The head is the largest segment. The body tapers gradually from the thoracic region hindwards. The young grubs are like ordinary cockchafer grubs with three pairs of thoracic legs.

The full-fed grub measures, when it walks on a flat surface, about 28 mm. in length. The head is brown yellow and its surface appears minutely pitted under lens ; on the vertex there is a longitudinal slit-like marking. The dorsal regions of the subsegments of the first six abdominal segments have minute bristle-like brown hairs though not

very densely. No other part of the dorsal or ventral surface except the hind end has such hairs. The hind end has a transverse slit; its dorsal margins are clothed in longish brown hairs and its ventral surface has short bristle-like hairs arranged over a space triangular in shape with the vertex of the triangle turned anteriorly. There are a few long hairs scattered on head and body. The spiracles are brown-yellow and crescent shaped; the concave side of the prothoracic spiracles is turned posteriorly and that of all abdominal ones anteriorly. The general colour of the body is pale yellowish white, that of the hinder part being dark. The legs are brownish and each of them has a distinct claw.

Alissonotum piceum.

This most probably has a lifehistory similar to that of *Alissonotum impressicolle.* A few beetles collected in May rested in the Insectary in the adult stage, one living until October, but no eggs were obtained.

Alissonotum simile.

This has probably a lifehistory similar to that of *A. piceum.* A larva collected from sugarcane fields at Kamrup on 20th May developed into a beetle on 16th June.

Xyleborus perforans, Woll.

Foodplants—Sugarcane.
Sal (*Shorea robusta*).
Anogeissus latifolia.
Areca catechu.

"In the course of the last four years during which especial attention has been paid to the insect pests of sugarcane, the Scolytid borer, *Xyleborus perforans*, Woll. (Plate IV), has only been observed once, in December 1919, in a variety of cane called B. 147, which was growing on the Chinsurah Farm. This beetle came into prominence over thirty years ago in connection with the destruction of beer-casks shipped into India and was investigated by W. F. H. Blanford, who considered *X. affinis*, attacking sugarcane in the West Indies, as a variety of *X. perforans.* In 1900 a *Xyleborus* was reported as boring sugarcane in Bengal and was considered to be either identical with, or closely allied to, *X. perforans.* In 1892 this beetle formed the subject-matter of a warning letter issued by the Revenue and Agriculture Department of the Government of India, which stated that this pest, notorious in the West Indies as a pest of sugarcane, had already been introduced

of the plants. Similarly sann-hemp and *Ageratum* plants were kept under insect-proof conditions.

The work was carried out at Pusa (Bihar) and most of the transmission experiments were performed during August-December, the usual period of active growth of tobacco crop in Bihar, as it is recognized [Smith, 1935] that it is difficult to infect mature plants with virus diseases.

The infected plants were kept under observation up to the middle of the following April for noting the appearance of the disease. By this date all the tobacco plants both in pots and in the field had flowered and formed capsules.

The variety of tobacco under investigation was H 142, which is the most common cigarette tobacco grown at the Botanical Sub-station at Pusa.

The symptoms of the various types of leaf-curl of tobacco have not been described in the following pages, as Pal and Tandon [1937] have already published a detailed account thereof. We may, however, state that almost all the types undergo some change with the growth of the tobacco plant and towards the end of the season show some symptoms which have been described by Pal and Tandon as characteristic of *X* type. It may also be added that *A* type always starts as *X* type and in the course of two or three weeks acquires the typical characteristic of *A* type, therefore the two types cannot be distinguished from each other for sometime except that the plants which are going to develop *A* type have more severe symptoms of *X* type than those which are going to remain of *X* type. We have observed the same changes in the field and, therefore, venture to suggest that the descriptions of various types given by Pal and Tandon need some modifications in reference to the changes which the types undergo during different seasons of the year.

III. Transmission of the disease from sann-hemp to tobacco

Five series of experiments were performed between September and the middle of December 1936 on tobacco seedlings, eight to sixteen weeks old. The diseased sann-hemp used as source for these experiments had been sown in the field about the 1st July. The detailed particulars of the experiments are given in Table I-A.

In the first series, seven experiments were performed between the 6th and 12th September, when sann-hemp and tobacco under experiment were both about eight weeks old. Two to five specimens of the white-fly were kept on a diseased sann-hemp plant for twenty-four to forty-eight hours before they were transferred to a healthy tobacco seedling. None of the seven infected seedlings developed the disease.

In the second series, eight experiments were performed between the 20th and 29th September with both sann-hemp and tobacco ten to twelve weeks old. Two to twelve white-flies were kept on diseased sann-hemp for eighteen to fifty-three hours before they were transferred to a healthy tobacco seedling. After about thirty-six days one seedling (No. 1) out of eight developed leaf-curl of *A* type.

The third series consisted of ten experiments performed in the beginning of November with tobacco and diseased sann-hemp being seven and seventeen weeks old respectively. Nine to twenty-six individuals were used and they were kept for 18½ hours on the diseased source. Five out of ten infected tobacco seedlings (Nos. 1 and 7—10) developed leaf-curl. Three seedlings developed leaf curl of *A* type, and in the other two the disease was of *X* type. Whereas in the seedlings which developed *A* type, the disease was evident in about seventeen to nineteen days only, in those which developed *X* type it took as many as seventy-four and eighty-four days to appear.

At about the same time (beginning of November), seven more experiments were performed (series IV) on sann-hemp and tobacco, both seventeen weeks old. Seven to seventeen white-flies which had fed for twenty-four hours on diseased sann-hemp were put on a healthy tobacco seedling. None of the seven infected plants developed leaf-curl.

Again about the middle of December when the diseased sann-hemp was about twenty-two weeks old, ten experiments were performed on about eight weeks old tobacco seedlings (series V). Two seedlings developed leaf-curl in thirty-seven and sixty-three days respectively. The disease was of *X* type.

All the controls in the five series of experiments described above remained free from leaf-curl.

From the foregoing it will be evident that in 1936, as in the previous year, the white-fly was found capable of transmitting the leaf-curl virus from diseased sann-hemp to healthy tobacco which consequently developed disease of *A* type in most cases. It will be further noticed that the highest percentage of positive results (50 per cent) was obtained if the tobacco seedlings were about seven weeks old at the time of infection, as was the case in series III. Experiments performed at the same time and under the same conditions as those in series III but on seventeen weeks old tobacco gave much fewer positive results.

In the course of experiments carried out in 1936 and described above it was observed that with diseased sann-hemp as the source, some of the infected tobacco seedlings developed *A* type while others developed *X* type. In 1937 the symptoms of leaf-curl of sann-hemp were carefully studied before experiments were performed. Two distinct types of the disease could be made out. In one the leaf blades were simply curled but not puckered and there was only a slight thickening and greening of the veins. The second type was much more severe and was characterised by distinct puckering and twisting of leaf blades. In Plate VII, figs. 1 and 2 the two types are illustrated. They are designated as S.V.1 and S.V.2 in the following pages.

Five series of experiments were performed during 1937, two using S.V.1 type and three with S.V.2 type as source. The particulars of experiments

under various series are given in detail in Table I-B, and are briefly summarized in the following statement :—

Main results of transmission experiments from sann-hemp to tobacco, during 1937 (detailed particulars in Table I-B)

Series	Time of experiment	Age of tobacco infected (weeks).	No. of white-flies and the period for which they fed on diseased sann-hemp	Type of disease used as source	No. of plants infected	No. of plants which developed disease and their type	Remarks
			No. / hrs.				
I	9th-11th Sept. 1937	8	6—14 / 29	S.V.1	12	10, *X* ; 2, *D* ?	One *D* recovered
	Do. . .	8	7—14 / 24	S.V.1	28	2, *X* ; 2, *X* ?	Three recovered
II	27th Sept. to 1st Oct. 1937	7	9—27 / 20—48	S.V.1	27	22, *X* .	
III	27th-29th Sept. 1937	7	10—27 / 20—48	S.V.2	3	2, *A*	
IV	31st Oct. to 2nd Nov. 1937	7	5—25 / 24—29	S.V.2	27	15, *A*	
V	25th-28th Nov. 1937	6	3—7 / 24	S.V.2	25	1, *A*	

N. B.—None of the controls developed leaf-curl.

From the foregoing it will be evident that the white-fly can transmit both types of leaf-curl from sann-hemp to tobacco, S.V.1 and S.V.2 types giving rise to *X* and *A* types respectively in tobacco. Photographs of the tobacco plants in which *A* type was produced by experiment are reproduced in Plate VIII, figs. 1*a-h*. Figs. *j-k* are of the controls.

The least amount of time tried for which the white-fly was kept on the diseased source before it was capable of transmitting the disease was twenty hours. The maximum number of positive results was obtained from September up to the middle of November, if the tobacco seedlings at the time of infection

were six to eight weeks old. During the second half of November and December, even if the infected tobacco was of this age, the percentage of positive results was smaller.

Thus the results obtained in 1936 and 1937 clearly confirm those of 1935 in that sann-hemp is an important host of some types of tobacco leaf-curl and that the white-fly, *Bemisia gossypiperda*, can easily transmit the disease from sann-hemp to tobacco.

IV. Transmission of the disease from tobacco to sann-hemp

It has been shown above that the white-fly can easily transmit leaf-curl of both types (S.V.1 and S.V.2) from sann-hemp to tobacco. During 1936, four series of experiments were performed to ascertain if this insect could transmit the disease in the opposite direction, *viz.*, from tobacco to sann-hemp. The detailed particulars of the experiments are given in Table II-A. One to thirty white-flies were kept on diseased tobacco of *A* and other types for eight to forty-eight hours and were then transferred to healthy sann-hemp plants, nine to sixteen weeks old. Thirty-two plants were thus infected between the 12th of September and 6th of November. The sann-hemp seedlings under inoculation had been sown in the beginning of July. Only three infected plants (series III, No. 1-3) showed some reaction but none developed typical leaf-curl.

The incidence of leaf-curl in sann-hemp crops at Pusa is very high during the last week of July and whole of August. For the disease which appears at this time, the infection probably takes place some time before the middle of July. The failure to transmit the disease from tobacco to sann-hemp in the experiments referred to above seemed to be probably on account of the fact that sann-hemp at the time of experiments (September-November) had passed the growth stage at which it was susceptible to the infection. We could not perform any transmission experiments during July as no diseased tobacco for using as source was available before September. However, we kept by careful tending some diseased tobacco plants of 1936 for performing experiments on sann-hemp during July-August of the next year (1937), which are described below.

With the diseased tobacco plants of 1936 as source, four series of experiments were performed during 1937, full particulars of which are given in Table II-B, and the results are briefly summarized in the following statement :—

Main results of transmission experiments from tobacco to sann-hemp during 1937 (detailed particulars in Table II-B)

Series	Time of experiment	Age of sann-hemp infected (weeks)	No. of white-flies and the period for which they fed on diseased tobacco	Type of disease used as source	No. of plants infected	No. of plants which developed disease and their type	Remarks
			No. / hrs.				
I	16th-17th July 1937	2½	2—6 / 4—16	*X*	17	1, S.V.1	
II	18th-23rd July 1937	2½—3	3—7 / 8—13	*C*	5	1, S.V.1	
	Do. . .	,,	,,	*A*	13	1, S.V.2	
	Do. . .	,,	,,	*X*	4	2, S.V.1	
III	23rd-29th July 1937	3—4	1—9 / 6—18	*C*	8	3, S.V.1	
	Do. . .	,,	,,	*A*	10	..	
	Do. . .	,,	,,	*D*	3	..	
	Do. . .	,,	,,	X	4	..	
IV	27th-31st Aug. 1937	8	2—25 / 6—17	*C*	3	1, S.V.1	
	Do. . .	,,	,,	*C*+*D*	6	1, S.V.1	
	Do. . .	,,	,,	*A*	13	6, S.V.2	
	Do. . .	,,	,,	*X*	2	..	

From the above statement it will be clear that white-fly could transmit leaf-curl from tobacco back to sann-hemp, though the proportion of positive results (about 18 per cent) was much smaller than in the case of the transmission of the disease from sann-hemp to tobacco. The disease generally appeared three to five months after infection. A typical sann-hemp plant in which leaf-curl (S.V.2 type) was produced by experiment is illustrated in Plate VII, figs. 4 and 4*a*.

It will be observed that when diseased tobacco used as source was of *A* type, sann-hemp developed S.V.2 type and when it was *X* or *C* type, it developed S.V.1 type.

From the review of the results obtained in 1936 and 1937 it is evident that sann-hemp can get the infection from tobacco generally during July and August only, and that too in a small number of cases. As diseased tobacco is not in the field in North Bihar before the end of September or October, there is very little chance of this crop acting as a source of infection for sann-hemp.

V. Transmission of the disease from sann-hemp to sann-hemp

In 1936 two series of experiments were performed to ascertain if the white-fly could transmit the virus from diseased sann-hemp to healthy sann-hemp. The particulars of the experiment are given in detail in Table III-A. The first series consisted of twenty-four experiments in which four to twelve specimens of the white-fly kept on a diseased plant for twenty-four hours (between the 8th-13th October) were put on a healthy plant which was thirteen to fourteen weeks old at that time. Four out of twenty-four plants thus infected (Nos. 1, 7, 8 and 19) showed leaf-curl almost similar to that of the source. The disease took 57, 29, 27 and 136 days respectively to appear. In all the cases the side shoots of the plants also showed leaf-curl. The second series consisted of ten experiments in which eleven to twenty-seven white-flies which had been allowed to feed on diseased plants for nineteen hours on 4-5th November were introduced on about four months old healthy plants. One plant (No. 9) showed leaf-curl on 6th December. Its side shoots were also diseased.

Thus the white-fly could transmit leaf-curl from diseased to healthy sann-hemp, though the percentage of successful transmissions was rather low (10-16 per cent).

In 1937 two series of experiments were again performed on the above lines to verify the results obtained in the previous year. The particulars of the experiments are set forth in Table III-B. In the first series, consisting of eight experiments, type S.V.1 was used as source. Infections were done in the first week of September when the infected plants were about nine weeks old. Two to five white-flies were kept on a diseased plant for twenty hours before they were transferred to a healthy plant. Two out of eight infected plants developed leaf-curl after seventy-one and seventy-nine days respectively.

In the second series, consisting of nine experiments, diseased plants of type S.V.2 were used as source. Other conditions, *e.g.*, the number of white-flies used, the period for which they were kept on the diseased plants, the age of the infected plants, etc., were the same as in series I above. Two out of nine infected plants developed leaf-curl similar to that of the source after sixty-seven to seventy-two days.

Thus the results of two years' experiments show that white-fly can transmit leaf-curl of both types from sann-hemp to sann-hemp, but the percentage of positive transmissions (10-20 per cent) is small.

Rhaconotus scirpophagae Wilksn.

Distribution.—This parasite is common at Lyallpur, but rare at Jullundur and Sonepat.

Insect hosts.—It attacks the larvae of *Scirpophaga nivella* Fab., *Emmalocera depresella* Swinh. and *Chilo trypetes* Bisset.

Bionomics.—It is active during October-March when it parasitizes 1-2 per cent of the hibernating host larvae, particularly those of *Scirpophaga nivella* Fab.

Goryphus sp.

Distribution.—This parasite is common at Jullundur, Lyallpur and Sonepat and rare at Gurdaspur.

Insect hosts.—It attacks the larvae of *Scirpophaga nivella* Feb. and *Chilo trypetes* Bisset.

Bionomics.—It is active during July-February : in 1934-35 and 1935-36 it parasitized respectively 13 and 3·2 per cent of the larvae of *Scirpophaga* during this period at Jullundur.

Stenobracon (*Glyptomorpha*) *desae* Cam.

Distribution.—It is common at Lyallpur and Sonepat but rare at Jullundur. It has also been recorded at Jhelum.

Insect hosts.—It parasitizes the larvae of *Scirpophaga nivella* Fab., *Argyria sticticraspis* Hampsn., *Chilo trypetes* Bisset, *Emmalocera depresella* Swinh. and *Chilo zonellus*, and the pupae of *Scirpophaga nivella* Fab.

Bionomics.—It is active from July to September.

Harmoniae sp.

Distribution.—It is common at Gurdaspur and Lyallpur but rare at Jullundur.

Insect hosts.—It parasitizes the larvae of *Scirpophaga nivella* Fab. and *Schaenobius bipunctifer* Wlk. (Rice borer : Pyralidae : Lepidoptera).

Bionomics.—It is active from September to February.

Chelonus sp.

Distribution.—This parasite has so far been collected from Sargodha only.

Insect hosts.—It parasitizes the larvae of *Scirpophaga nivella* F. and *Emmalocera depresella* Swinh.

Bionomics.—It was collected from the larvae of *Scripophaga* in October and from those of *Emmalocera* in April.

3. Family Encyrtidae

Ooencyrtus papilionus Ashm.

Distribution.—This parasite is uniformly distributed in the Punjab.

Insect host.—It is a very important egg parasite of *Pyrilla perpusilla* Wlk.

Bionomics.—The parasite is scarce during April-June. It becomes active in July, but it reaches its peak during the period from September to December when, along with *Tetrastichus pyrillae* Craw., it may parasitize 79 per cent, with an average of 30 to 40 per cent, of *Pyrilla* eggs. There is considerable reduction in its numbers during January-March, when it is found in sugarcane trash.

VI. Transmission of the disease form tobacco to tobacco

To ascertain the role played by the white-fly in the transmission of leaf-curl of various types from diseased to healthy tobacco plants, seven large series of experiments were performed at different times during 1936, the particulars of which are given in detail in Table IV-A and the results are summarized briefly in the following statement :—

Main results of the experiments performed for the transmission of leaf-curl from diseased to healthy tobacco during 1936 (detailed particulars in Table IV-A)

Series	Time of experiment	Age of tobacco infected. (weeks)	No. of white-flies and period for which they were fed on diseased plant	Type of disease used as source	No. of plants infected	No. of plants which developed the disease of various types	Remarks
1	2	3	4	5	6	7	8
			No. / hrs.				
i	14th-29th Sept. 1936	9—11	5 / 19	*B*	3	*Nil*	...
			3—12 / 16—48	*C*	8	1, *C*	
			1—3 / 16—17	*X*	6	1, *X*	
ii	8th-15th Oct. 1936	12—13	3—5 / 8—9	*A*	5	1, *X*	The source was not pure *A*.
			1—7 / 24	*B*	5	*Nil*	
			3—6 / 8—24	*C*	7	*Nil*	
iii	16th-17th Oct. 1936	9	2—5 / 7—8	*X*	4	2, *X*	
iv	28th Oct.-6th Nov. 1936	6—7	7—9 / 24	*A*	5	2, *C*; 1, *X*	The source was not pure *A*.
			3—13 / 5—24	*B*	16	5, *B*; 1, *AX*	
			4—12 / 5—24	*C*	24	3, *C*; 1, *X*; 2, *C*+*D*	
			4—7 / 24	*CX*	2	1, *CX*; 1, *CD*	
			26—33 / 21	*A*+*B*+*C*+*D*	4	2, *X*	The vectors were fed alternately on diseased plants of types *A*, *B*, *C* and *D* before being put on healthy plant.

Series	Time of experiment	Age of tobacco infected. (weeks)	No. of white-flies and period for which they were fed on diseased plant	Type of disease used as source	No. of plants infected	No. of plants which developed the disease of various types'	Remarks
1	2	3	4	5	6	7	8
			No. / hrs.				
v	14th-16th Dec. 1936	8	3—16 / 6—24	*A*	8	*Nil*	
			3—11 / 6—24	*B*	8	2, *B*	
			5—13 / 6—24	*C*	8	2, *C*	
			4—14 / 6—7	*D*	8	*Nil*	
vi	25th Dec. 1936 to 5th Jan. 1937.	6—8	4—7 / 18	*A*	10	2, *A* ?	
			2—5 / 24	*B*	8	1, *B* ?	
			3—9 / 18—24	*C*	18	1, *C*	
			4—9 / 6	*D*	10	1, *D* ?	
			2—8 / 24	*X*	8	1, *X*	
			11—24 / 6	*A*+*B*+*C*+*D*	7	3, *X*	The synthetic source as in Ser. *iv*.
			9—15 / 6	*A*+*C*	3	1, *X*	The synthetic source as in Ser. *iv*.
			7—11 / 6	*A*+*D*	3	2, *X*	The synthetic source as in Ser. *iv*.
vii	6th-9th Feb. 1937	7	4—11 / 18	*A*	15	1, *X*	
			4—12 / 18	*B*	15	4, *B*	
			5—13 / 18	*C*	15	*Nil*	
			6—11 / 18	*D*	20	3, *X*, 2, *D* ?	
			5—9 / 24	*X*	15	5 *X*	

From the statement given above it will be noticed that though on the whole the percentage of positive results obtained was rather low, white-fly could transmit all types of leaf-curl from diseased to healthy tobacco individually and synthetically. Furthermore, it is evident that the fly was most capable of transmitting the disease between the end of September and the middle of November and that tobacco was most susceptible to developing the disease if it was infected when about eight weeks old. Both the time of the year and the stage of growth of tobacco plants when the infections are made thereto have important influence on the development of the disease. The percentages of positive results from infections made during second half of September, October-November and December-January, were 12, 35-50 and 12-18·7, respectively, the tobacco plants under experiment being about seven to nine weeks old. In the case of infections under series (II), which were made between 8-15th October, but with twelve to thirteen weeks old tobacco, the percentage of positive results was 6 only.

Tobacco plants in which leaf-curl of various types was developed by experiment are illustrated in colour in Plates IX-X, showing their characteristic features in detail. Figs. 3 and 4 are of the *B* and *C* types, and Fig. 2 of the leaves of *A* type; the *A* type plant was similar to that in Fig. 1 of which the source was sann-hemp. Figs. 8 and 7 are of *X* (synthetically produced from *A*+*B*+*C*+*D*) and of true *X* (as occurs in nature) respectively. The differences between the appearance of the two plants are noteworthy, indicating that the composition of *X* type considered to be mixture of all types by Pal and Tandon needs accurate determination.

In 1937 three large series of transmission experiments were performed to verify the results obtained in the previous year. In the 1937 season, however, tobacco plants available for experiments were rather poor in growth and did not react to infection properly. It is widely recognised that for proper reaction to virus infection the infected plant must be growing actively [Smith, 1935]. Moreover, as plants in the field did not show leaf-curl up to the middle of October no infections could be made before that date. Particulars of the various series are given in Table IV-B.

In the first series, seventeen infections using *D* type as source were done on nine weeks old seedlings. Four to nine specimens of white-fly which had been allowed to feed on the diseased source for seven to twenty-four hours, were put on each healthy plant. In thirty-two to thirty-four days two out of seventeen infected plants developed the disease of *X* type. In the same series three plants were infected at the same time as the above, but with *X* type as source. Four to six white-flies were allowed to feed on diseased tobacco for twenty to twenty-four hours. None of the infected plants developed leaf-curl.

In the second series thirty-five infections were done in the beginning (5-9th) of November, using different types of disease as source. Only two infected (with *C* type) plants developed disease in twenty-five and thirty

days. One was almost true to the source but recovered later and the second one showed symptoms of *X* type.

The third series was performed in the end of November (29th November to 1st December). Twenty-five infections were done, but none of the infected plants developed leaf-curl.

Thus white-fly was capable of transmitting leaf-curl from diseased to healthy tobacco plants though the percentage of positive results obtained was extremely low. This, as pointed out above, was perhaps due to the poor growth of the plants under experiment as well as to the fact that the infections were done rather late in the season.

VII. *Ageratum conyzoides*, a new important host of the tobacco leaf-curl virus

In December 1936 while making survey of the weeds which showed leaf-curl it was observed that *Ageratum conyzoides*, a very common weed at Pusa, was suffering from leaf-curl with symptoms resembling those of some types of diseased tobacco. Healthy leaf and diseased plant of the weed are illustrated in detail in Plate VII, figs. 5 and 5*a*-*b*. Some transmission experiments were performed on the 16-17th December to ascertain if this plant like sann-hemp was an alternate host of the tobacco leaf-curl virus and if the white-fly could transmit the disease from *Ageratum* to tobacco. The detailed particulars of the experiments are given in Table V. Six to sixteen specimens of white-fly were fed on diseased *Ageratum* for twenty-five hours and then transferred to a healthy tobacco seedling about nine weeks old. Six plants were infected in this way. About the 18th January two infected plants showed leaf-curl of *D* type. The other four seedlings and the controls were kept under observation up to the end of the season but did not show any symptoms of leaf-curl.

In 1937 four large series of experiments were performed to verify the above results. The particulars of these experiments are also detailed in Table V, and the results are briefly summarized below :—

In the first series, forty infections were made in the first week (5-8th) of September on about eight weeks old tobacco plants. Two to sixteen white-flies were fed on diseased *Ageratum* for sixteen to twenty-five hours before they were transferred to a healthy tobacco seedling. In the course of thirteen to eighty-three days, twenty-four out of forty infected plants developed leaf-curl, and in almost all the cases the disease was of *D* type.

About the end of September (26-28th), thirty more infections (second series) were made on about six weeks old seedlings. Six to twenty-six white-flies were used per plant and they were allowed to feed on diseased *Ageratum* for twenty to twenty-five hours. In eleven to thirty-three days, eight of the infected plants developed leaf-curl, in almost all cases the type again being *D*.

The third series consisted of twenty experiments in which five to thirteen white-flies which had fed on diseased *Ageratum* for twenty-four to forty-four hours were used per plant. The infections were done in the first week of November. Between twenty-four and thirty-three days, four of the infected plants developed leaf-curl of *D* type.

The fourth and the last series of experiments consisting of thirty infections was performed on six weeks old tobacco seedlings. One to eight specimens of white-fly were used per plant. They were kept on diseased *Ageratum* for twenty-four to forty-two hours. In the course of nineteen to thirty-two days, twelve of the infected plants developed leaf-curl of typical *D* type.

From the foregoing it will be evident that *Ageratum conyzoides* is an important alternate host of the tobacco leaf-curl virus *D* and that white-fly can transmit the disease from this host to tobacco very easily. In some of the experiments described above the percentage of positive result was as high as 60. It may be recalled that Thung [1934] working in Java also successfully transmitted leaf-curl virus from this weed to tobacco with a white-fly as vector, though the highest percentage of positive infections obtained by him was about 18 only. Massop [1932] also suspected a species of *Ageratum* to be a host of tobacco leaf-curl virus in Rhodesia.

VIII. Transmission of the disease from tobacco to *Ageratum conyzoides*

Having successfully transmitted the disease from *Ageratum* to tobacco with the help of white-fly, it was natural to ascertain if the disease could be transmitted back from tobacco to *Ageratum*. Therefore about the end of October (29-30th), 1937, a series of experiments was performed for this purpose. The particulars of the experiments are detailed in Table VI. The weed which had been specially grown for experimental purposes was about eleven weeks old at the time of infection. Two to nine specimens of white-fly were allowed to feed on diseased tobacco of *D* type and then transferred to a healthy seedling of the weed. Nine infections were made in this way. In fifteen to forty-seven days all the nine infected plants developed leaf-curl resembling that which occurs in the field (Plate VIII, fig. 4).

IX. Transmission of the disease from *Ageratum conyzoides* to sann-hemp and back to the weed

Sann-hemp and *Ageratum* having definitely proved to be alternate hosts of tobacco leaf-curl, infections were made to determine the relationship of the viruses in the two alternate hosts. In the first week of September 1937, eighteen sann-hemp plants about nine weeks old were infected. Two to seven white-flies which had been allowed to feed for eighteen to twenty-three hours on diseased *Ageratum* were put on each sann-hemp plant. In seventy-two to seventy-eight days two infected plants developed leaf-curl of S.V.2 type (Table VII). In one case side shoots also showed the disease.

On 11th and 12th October two series of experiments were performed to determine if the disease could be transmitted by white-fly from sann-hemp (of both S.V.1 and S.V.2 type) to *Ageratum*. Twenty out of twenty-one infected plants of the weed developed typical leaf-curl in 38-100 days (Table VIII). In Plate VIII, figs. 2 *a-b*, photographs of some of the plants in which the disease was produced by experiment are reproduced.

X. Transmission of the virus from diseased weed (*Ageratum conyzoides*) to healthy weed

Experiments were also performed to ascertain the role of white-fly as a transmitter of the virus from diseased to healthy weed. Twenty-four infections were made during the month of October 1937, using five to eleven specimens of the white-fly per plant, which had been allowed to feed on diseased weed for about twenty-four hours. In thirteen to seventy-one days, twenty-three out of twenty-four infected plants developed leaf-curl similar to that which occurs in nature. The particulars of the experiments are given in detail in Table IX. In Plate VIII, figs. 3 *a-b*, photographs of some plants in which the disease was produced by experiment and of two control plants (figs. 3 *c-d*) are reproduced.

Thus the experiments described above clearly show that *Ageratum conyzoides* is a very important alternate host of the tobacco leaf-curl virus and that white-fly can easily transmit the virus from this weed to tobacco and sann-hemp and back from these hosts to the weed as well as from diseased to healthy weed plants.

XI. Number of white-flies and their period of feeding on diseased source necessary for the transmission of leaf-curl and the incubation period of the disease inside the plant

We have not yet performed exact experiments to ascertain the minimum number of white-flies and the period of their feeding on diseased source which are necessary for successfully transmitting leaf-curl to tobacco, sann-hemp and *Ageratum*. Similarly, no special experiments have been performed to determine the minimum and maximum incubation periods of the disease inside the infected plants at different times of the year. However, the detailed particulars of the numerous experiments which are given in Tables I-IX, and which have been summarised in the previous pages, throw some light on the factors named above. The particular experiments under various series which give information about these factors are incorporated in the statements given below. The minimum number of white-flies tried and found successful in transmitting the disease to various hosts is shown in column 5 of the statements. The minimum period of time tried for which the known number (given in colunn 4) of white-flies fed on diseased source and transmitted the disease is shown in column 7, the minimum and maximum incubation periods of the disease inside the various plants are stated in columns 9 and 10. It was noticed that when the number of white-flies under trial

was the minimum, the period for which they fed to become viruliferous was not necessarily the least, neither was so the incubation period. Therefore for each pair of plants (the source and the infected plant) generally four experiments give the necessary information about the four factors named above, *viz.*, minimum number of white-flies tried, minimum period of feeding tried, minimum and maximum incubation periods of the disease. In a few cases only one experiment was found to give information about more than one factor. In such cases two or three experiments give the necessary information and have only been included in the statements. In the case of crops like tobacco and sann-hemp which have more than one type of leaf-curl, information on the factors referred to above is given separately for each type. The data given in the statements are briefly summarized below :—

Transmission of the disease from sann-hemp to tobacco (Statement I)

The least number of individuals tried which successfully transmitted the disease of S.V.2 type was five. They had been kept on the diseased source for twenty-five hours and the incubation period of the disease in this case was thirty-six days which proved to be the maximum for this type. The minimum period of feeding on diseased source in the case of successful transmission was 20½ hours, the number of specimens used being ten. A smaller number was not tried. The minimum incubation period was eleven days and was so in the case of the experiment in which the white-flies had fed for the minimum period.

With diseased sann-hemp of S.V.1 type as source, the least number of specimens tried which successfully transmitted the disease was six. The minimum period of feeding was 18½ hours, using seventeen individuals. The maximum and minimum incubation periods were eighty-four and eight days respectively. It is noteworthy that in the case of both types the minimum incubation period of the disease inside tobacco was noted when the plants were infected towards the end of September (27-29th September, 1937).

Transmission of leaf-curl from tobacco to sann-hemp (Statement I)

Type A.—The minimum number of white-flies tried and found successful was two. They had fed for about seventeen hours. The minimum feeding period successfully tried was thirteen hours, using three specimens. The incubation period varied between 53 and 112 days, the time of infection being from the end of July up to end of August.

Statement I

Serial No.	Time and source of infection and infected plant	Type of disease of source	No. of white-flies used	Minimum No. of white-flies tried which transmitted disease	Feeding period	Minimum feeding period tried resulting in successful transmission	Incubation period	Minimum incubation period	Maximum incubation period	Type of disease appearing and remarks
1	2	3	4	5	6	7	8	9	10	11
					Hrs.		Days	Days	Days	
	Sann-hemp to tobacco									
1	24th September 1936 .	S.V.2 .	5	5	25	...	36	...	36	*A*
2	27th September 1937 .	Do. .	10	...	20½	20½	11	11	...	*A*
3	27th September to 1st November 1937.	Do. .	7—13	...	20½—24	...	11	11	...	*A*
1	14th December 1936 and 9th September 1937.	S.V.1 .	6	6	24, 29	...	39, 63, 13	...	...	*X*
2	4th November 1936 .	Do. .	26	...	...	18½	84	...	84	*X*
3	29th September 1937 .	Do. .	13—27	...	48½	...	8	8	...	*X*
	Tobacco to sann-hemp									
1	27th to 30th August 1937	*A* . .	2	2	16½—17	...	53, 84	53	...	S.V.2
2	21st July 1937 . .	*A* . .	3	...	13	13	...	...	112	
1	16th July 1937 . .	*X* . .	6	...	6	6	117	117	...	
2	18th July 1937 . .	*X* . .	3	3	8	...	122	...	122	
	Sann-hemp to sann-hemp									
1	3rd September 1937 .	S.V.1 .	2	2	20	...	71	...	...	
2	5th November 1936	Do. .	24	...	19	19	31	...	...	
	11th October 1936 .	Do. .	10	...	24	...	27	27	...	
	13th October 1936 .	Do. .	5	...	24	...	136	...	136	

Type X.—The minimum number of white-flies tried which successfully transmitted the disease was three. They had fed for eight hours and the incubation period in that case was 122, which was the maximum for this type. The minimum feeding period tried was six hours, the number of individuals used being three.

Transmission of the disease from sann-hemp to sann-hemp (Statement I)

The minimum number of specimens tried and found successful was two. They had fed on diseased source for twenty hours. The minimum period for which white-flies were fed and transmitted disease was nineteen hours. A shorter feeding period was not tried. The incubation period varied between 27 and 136 days.

Transmission of the disease from tobacco to tobacco (Statement II)

Type A.—The least number of individuals tried and found successful was three. They had fed for eight hours. which was the minimum period tried for this type. The incubation period varied between seventeen and ninety-four days, the minimum and maximum being with the infections done in the beginning of February and during December respectively.

Type B.—The minimum number of white-flies tried and found successful was six. They had fed for twenty-four hours. The minimum feeding period tried was six hours, using six to seven individuals. The incubation period varied between 18 and 110 days, the minimum again being in the case of the infection which was done in the beginning of February.

Type C.—The minimum number of specimens and the minimum period of feeding tried and found successful were five, and five hours respectively. The incubation period varied between twelve and fifty-nine days, the minimum and maximum being in the case of the infections done in the end of October and during December respectively.

Type D.—The least number of specimens tried which transmitted the disease was four. They had fed for six hours, which was the minimum period tried for this type. The incubation period varied between twenty and ninety-four days, the minimum and maximum being in the case of the infections which were done in the beginning of February and during December respectively.

When the disease was produced synthetically by feeding the white-fly on types *A*, *B*, *C* and *D* successively, the minimum number of specimens which were tried and transmitted the disease was thirteen, the minimum feeding period tried being six hours on each type. The incubation period varied between 37 and 140 days.

From the foregoing it will be clear that as few as two flies could successfully transmit the disease. The minimum feeding period tried giving rise to successful transmission was five hours. The incubation period varied from 12 to 140 days, the minimum and maximum being generally in the case of those infections which were done in the beginning of February and during December respectively.

Statement II

Serial No.	Time and source of infection and infected plant	Type of disease of source	No. of white-flies, used	Minimum No. of white-flies tried which transmitted disease	Feeding period	Minimum feeding period tried resulting in successful transmission	Incubation period	Minimum incubation period	Maximum incubation period	Type of disease appearing and remarks
1	2	3	4	5	6	7	8	9	10	11
					Hrs.		Days	Days	Days	
	Tobacco to tobacco									
1	15th October 1936 .	*A* . .	3	3	8	8	26	...	...	*A* ? Source also slightly mixed
2	6th February 1937 .	*A* . .	9	...	18	...	17	17	...	*A* ?
3	25th December 1936 .	*A* . .	5	...	18	...	94	...	94	*X*
1	1st November 1936 .	*B* . .	6	6	24	...	36	...	...	*B* ?
2	16th December 1936 and 4th January 1937.	*B* . .	6—7	...	6	6	68	...	...	*B*
3	6th February 1937 .	*B* . .	7	...	18	...	18	18	...	*B*
4	1st November 1936 .	*B* . .	11	...	24	...	110	...	110	*B*
1	31st October 1936 to 16th December 1936.	*C* . .	5	5	24—26	...	37—59	...	59	*C*
2	28th October 1936 .	*C* . .	10	...	5	5	18	...	...	*C*
3	31st October 1936 .	*C* . .	7	...	24	...	12	12	...	
1	26th December 1936 and 14th October 1937.	*D* . .	5	4	6—7	6	94, 34	...	94	*D* ?
2	6th February 1937 .	*D* . .	7	...	18	...	20	20	...	*D*
1	16th October 1936 .	*X* . .	2	2	7½	7½	25	...	25	*X*
2	8th-9th February 1937.	*X* . .	5	...	24	...	11	11	...	*X*
1	27th December 1936 .	*A*+*B*+*C*+*D*	13	13	6	6	52	...	...	*X*
2	Ditto . .	Do. .	21	...	6	...	37	37	...	*X*
3	5th November 1936 .	Do. .	26	...	21	...	140	140	140	*X*

The life-cycle of the parasite is completed in 10-64 days depending upon the season as is clear from Table II. The female lives for about five days during April-October and about 24 days during the cold weather. The highest number of eggs laid by a female in confinement was 30.

TABLE II

Duration of the life-cycle of Ooencyrtus papilionus *Ashm. at Lyallpur*

Date of oviposition by the adult parasite	Date of emergence of the adult parasite	Duration of life-cycle (in days)
21 Aug.	31 Aug.	10
4 Oct.	20 Oct.	16
3 Nov.	28 Nov. to 2 Dec.	25—29
23 Nov.	26 Jan.	64

Ascogaster sp.

Distribution.—It has so far been collected from Lyallpur only.

Insect host.—It parasitizes the larvae of *Emmalocera depressella* Swinh.

Bionomics.—The bionomics of this parasite has not been studied so far. It was found active in June.

Dipterous tachinida

Distribution.—It occurs at Lyallpur but is rare.

Insect hosts.—It parasitizes the caterpillars of *Sesamia uniformis* Dudgn.

Bionomics.—It was collected in July.

4. Family Eulophidae

Tetrastichus pyrillae Craw.

Distribution.—This parasite is widely distributed in the Punjab.

Insect host.—It parasitizes the eggs of *Pyrilla perpusilla* Wlk.

Bionomics.—*T. pyrillae* Craw. is active throughout the year. Its life-cycle is completed in 11-23 days, depending upon the season, as is seen from Table III.

TABLE III

Duration of life-cycle of Tetrastichus pyrillae *Craw.*

Date of oviposition by the adult parasite	Date of emergence of the adult parasite	Duration of life-cycle (in days)
23 April	5 May	12
24 April	5 May	11
28 Sept.	9 Oct.	11
19 Oct.	5 Nov.	17
8 Nov.	1 Dec.	23

Seasonal abundance of the egg parasites of Pyrilla perpusilla *Wlk.*—Observations on the yearly fluctuation in the population of *Pyrilla* egg parasites were made during 1926-34 at Lyallpur and the results are given in Table IV.

Statement III

Serial No.	Time and source of infection and infected plant	Type of disease of source	No. of white-flies used	Minimum No. of white-flies tried which transmitted disease	Feeding period	Minimum feeding period tried resulting in successful transmission	Incubation period	Minimum incubation period	Maximum incubation period	Type of disease appearing and remarks
1	2	3	4	5	6	7	8	9	10	11
					Hrs.		Days	Days	Days	
	Ageratum to tobacco									
1	22nd November 1937	...	1	1	24	...	19	...	...	*D*
2	7th -8th September 1937	...	5—16	...	16	16	13—83	...	...	*D*
3	Ditto	...	8	...	16	...	13	13	...	*D*
4	Ditto	...	11	...	16	...	83	...	83	*D*
	Tobacco to Ageratum									
1	29th and 30th October 1937	*D*	2—9	2	16	16	15—47	...	...	Resemble that in the field.
2	Ditto	...	...	...	...	...	15	15	...	
3	Ditto	...	...	...	...	...	47	...	47	
	Ageratum to sann-hemp									
1	3rd September 1937	...	3	3	23	...	78	...	78	S. V. 2
2	4th September 1937	...	5	...	18	18	72	72	...	S. V. 2.
	Sann-hemp to Ageratum									
1	11th-12th October 1937	S. V. 1	5—12	5	24	24	49—69	...	...	Type resembles that in the field.
2	Ditto	Do.	...	...	...	...	49	49	...	
3	Ditto	Do.	...	...	...	...	69	...	69	
1	Ditto	S. V. 2	5—11	5	24	24	38—100	...	...	
2	Ditto	Do.	...	...	24	...	38	38	...	
3	Ditto	Do.	...	...	24	...	100	...	100	
	Ageratum to Ageratum	...	5—11	5	24	...	13—71	...	...	
1	10th and 11th October 1937	...	...	...	...	...	13	13	...	
2	Ditto	...	...	...	...	...	71	...	71	
3	29th-31st October 1937.	...	6—10	...	22—24	22	27—39	...	...	

Transmission of the disease from Ageratum *to tobacco, sann-hemp,* Ageratum *etc.* (*Statement III*)

Even one white-fly which had been fed for twenty-four hours on diseased *Ageratum* successfully transmitted the disease to tobacco. However, the minimum feeding period successfully tried was sixteen hours, using five individuals. The incubation period varied between thirteen and eighty-three days.

In the case of tobacco to *Ageratum*, the minimum number of individuals successfully tried was two. They had fed for sixteen hours.

The minimum incubation period with tobacco and *Ageratum* as host and source respectively and *vice versa* was generally thirteen to fifteen days. In the case of *Ageratum* and sann-hemp, however, it was thirty-eight to forty-nine days.

XII. Other food plants of white-fly, *Bemisia gossypiperda* M. & L.

In addition to tobacco, *Ageratum conyzoides* and sann-hemp mentioned in the previous pages, white-fly has been found feeding and breeding on a variety of plants, both cultivated and wild, in the neighbourhood of Pusa. The list of various plant hosts is given below, and those which have been observed to suffer from some kind of leaf-curl have been marked with an asterisk :—

Cultivated plants

* *Althaea rosea* (hollyhock)
Cannabis sativa (*ganja*)
Hibiscus cannabinus
H. esculentus (lady's fingers)
Gossypium herbaceum (cotton)
* *Cucumis sativa* (cucumber)
C. melo (melon)
* *Lagenaria vulgaris* (bottle gourd)
Trichosanthes dioica
**Lycopersicum esculentum*
Nicotiana glauca
N. rustica
N. glutinosa
Capsicum annuum
Solanum tuberosum (potato)
S. melogena (brinjal)
Glycine hispida (soya bean)
* *Phaseolus calcaratus*
P. radiatus (green gram)
P. mungo (black gram)
Medicago sativa (lucerne)
Trifolium alexandrinum (berseem)
* *Zinnia elegans*
* *Petunia* sp.

Wild plants

Hibiscus rosasinensis (shoe flower)
* *Sida rhombifolia*
Nicotiana plumbaginifolia (wild tobacco)
**Solanum nigrum*
S. verbasiofolium
* *Datura stramonium* (datura)
Launea asplenifolia
Duranta plumieri (duranta)
Euphorbia hirsuta
Anisomeles ovata (wild bur)
Nepeta ruderalis
* *Scoparia dulcis*
Vernonia cinerea var. anthelmentica
Ocimum sanctum
Ocimum basilicum.

Cultivated plants

Arachis hypogea (groundnut)
Cajanus cajan (red gram)
Luffa acutangula (ribbed gourd)
Cucurbita maxima (pumpkin)

As is well known this white-fly is a serious pest of cotton in the Punjab. Husain and Trehan [1936] have given a complete list of its host plants in that province. However, this white-fly is not reported to cause leaf-curl in cotton or tobacco in the Punjab. Whereas cotton has been carefully examined for leaf-curl, a survey of tobacco areas for the incidence of leaf-curl is warranted, as one of us (H. S. P.) has recently observed a crop of tobacco badly affected by leaf-curl of all types near Agra in the western United Provinces.

XIII. Discussion and conclusions

From the observations described in the previous pages the following conclusions can be drawn :—

Sann-hemp is an important alternate host of the tobacco leaf-curl viruses *A* and *X*, the two viruses causing different symptoms in sann-hemp, giving rise to two types of disease, which have been designated as S. V. 1 and S. V. 2 in the paper. White-fly, *Bemisia gossypiperda*, can easily transmit both types of disease from sann-hemp to tobacco.

Though white-fly can transmit leaf-curl from tobacco back to sann hemp, it does not however seem to be a very efficient vector in this respect Moreover, in view of the fact that the times of growth of the two crops are different, tobacco does not seem to serve as a source of infection for the disease in sann-hemp.

The weed *Ageratum conyzoides* is another important alternate host of tobacco leaf-curl, especially of *D* type. White-fly is capable of easily transmitting the disease from this host to tobacco. White-fly can also easily transmit the disease from tobacco back to the weed. Sometimes 100 per cent positive transmissions were obtained. White-fly is capable also of easily transmitting the disease from sann-hemp to *A. conyzoides*, though it cannot transmit the disease back to sann-hemp so easily.

Regarding the role of white-fly as a vector of leaf-curl from diseased to healthy tobacco, the results of two years' experiments show that white-fly could transmit the disease only in a few cases. Therefore, it appears that in nature diseased tobacco is not an important source of infection for healthy tobacco, and that the alternate hosts referred to above, *viz.*, sann-hemp and *A. conyzoides* seem to play a much more important part in this connection. These two hosts harbour leaf-curl viruses *A*, *D* and *X* types ; the alternate hosts, if any, for *B* and *C* types remain yet to be discovered. In Java also it has been shown [Thung, 1932 ; 1934] that the chief source of infection to tobacco lies outside the crop.

It appears that tobacco is most susceptible to getting the infection if it is about eight weeks old and if the infection takes place in autumn or in February. Sann-hemp is most susceptible during July and August, when

it is about two to three months old. Wille [1928] working on ' leaf-crinkle ' of sugar beet also concluded that the disease is very much influenced by the age of the host plant, while Spencer [1938] has recently observed seasonal variations in susceptibility of tobacco to infection with tobacco-mosaic virus. Regarding the autumn and spring seasons being more suitable than winter for the infection of tobacco *, it is likely that the air temperature and humidity prevailing during these seasons are conducive to the development of the disease. In this respect the case of tobacco leaf-curl seems to be similar to that of mosaic disease of some Cruciferae in the United States, which is very severe if the temperature is 70°-80° F., whereas at 55°-65°F. even more susceptible hosts cease to show mosaic symptoms. It may also be recalled that ' yellow dwarf ' of potatoes in America develops severe symptoms at 25°C., while no symptoms appear at 15°C. [Goss and Peltier, 1925]. The ' curly top ' of sugar beet also behaves similarly [Smith, 1933]. Grainger [1936] has recently observed the same phenomenon in the case of tobacco mosaic. However, there are numerous cases on record [Smith, 1933] in which opposite is the case, *viz.*, low temperatures accentuate the symptoms of the disease, whereas higher temperatures suppress them.

The incubation period of the disease inside the infected plant seems to be connected with the question of the accentuation or suppression of the symptoms of the disease discussed above. It was noticed that with the age of infected tobacco remaining the same, the incubation period was generally minimum if the infections were done during September and October or in February when the air temperature starts rising at Pusa. The incubation period was generally the maximum if the infections were done during December. Spencer [1938] has recently found the same in the case of tobacco-mosaic virus. Apart from air temperature affecting the plant, it is quite likely that white-fly is most viruliferous at these times of the year, which again may be due to several environmental factors including temperature and humidity. Storey [1933] attached great importance to the influence of weather condition on the ability of the insect vector to take up and transmit viruses.

We have not performed exact experiments to determine the length of time necessary for white-fly to feed on the diseased host for successfully transmitting the disease to healthy host, but the general transmission experiments show that white-fly can transmit the virus after five to six hours' feeding, shorter periods not having been tested. Kirkpatrick [1931] found this period to be about 4½ hours in the case of the white-fly (*Bemisia* sp.) which spreads leaf-curl of cotton in Sudan. Storey [1928] showed that the leaf-hopper *Cicadulina mbila* could acquire the maize streak virus after one hour's feeding, whereas Doolittle and Walker [1928] concluded that *Aphis gossypii* could pick up the cucumber mosaic virus after feeding for five minutes only. Recently, Watson [1936] has obtained the highest proportion of infection after two to five minutes feeding by *Myzus persicae* on the infected plants.

* We could not perform any experiment during the hottest season of the year (April-June) as tobacco crop is not grown at that time in Bihar.

The minimum number of white-flies tested and found successful for the transmission of the disease from sann-hemp to tobacco was five; for the transmission from tobacco to sann-hemp and from sann-hemp to sann-hemp the number was two. Fewer numbers in all these cases were not tested. In the case of *Ageratum* to tobacco one white-fly was found to be able to transmit the disease.

It was observed that with the minimum number of white-flies tried which successfully transmitted leaf-curl, the incubation period of the disease inside the infected plant was generally not the shortest. It appears that the period of feeding remaining the same, there is no relation between the number of infected individuals used and the incubation period of the disease.

In addition to sann-hemp and *Ageratum conyzoides*, we have observed white-fly breeding on a number of plants, some of which (Cucurbits, hollyhock, zinnia, *Scoparia*, *Sida* sp., etc.) show leaf-curl, which may be closely allied to, if not identical with, tobacco leaf-curl. Therefore it appears that unlike most viruses, the tobacco leaf-curl viruses may have a big host range and thus resemble those of aster yellows, tomato spotted wilt, tobacco ring spot, etc. If this is true, the problem of the control of the disease by the eradication of alternate host plants becomes very difficult and the chances of success by keeping white-fly under check with insecticides appear to be greater.

XIV. Acknowledgments

We are thankful to the Imperial Economic Botanist for making arrangements for the supply of tobacco seedlings for our experiments and for affording other facilities at the Botanical Substation at Pusa. Mr. K. L. Khanna, Sugarcane Expert, Bihar, Pusa, was kind enough to loan us the services of his photographer for a few days.

REFERENCES

Doolittle, S. P. and Walker, M. N. (1928). Abstr. in *Phytophatt.* **18**, 143
Goss, R. W. and Peltier, G. L. (1925). *Nebroska Agric. Expt. Stn. Res. Bull.* No. **29**
Grainger, J. (1936). *Nature* **137** (3453), 31-32
Husain, M. A.; Trehan, K. N. and Verma, P. M. (1936). *Ind. J. Agric. Sci.* **6**, 893-903
Kirkpatrick, T. W. (1931). *Bull. Ent. Res.* **22**, 323-363
Massop, (1932). *Rhod. Agric. J.*, **29**, 869-872
Pal, B. P. and Tandon, R. K. (1937). *Ind. J. Agric. Sci.* **7**, 363-393
Pruthi, H. S. and Samuel, C. K. (1937). *Ind. J. Agric. Sci.* **7**, 659-670
Smith, K. M. (1931). *Biol. Rev.* **6**, 302-44
———— (1933). "Recent Advances in the Study of Plant Viruses." Churchill, London
———— (1935). "Plant Viruses". Methuen, London
Spencer, E. L. (1938). *Phytopl.* **28**, 147-150
Storey, H. H. (1928). *Ann. Appl. Biol.* **15**, 1-25
———— (1933). *Proc. Roy. Soc.* **B, 113**, 463-485
———— (1935). *East Afr. Agric. J.* **1**, 148-53
Thung, T. H. (1932). *Meded. Proefst. Vorsteulandsche Tobak, No.* **72**, 54 pp.
———— (1934). *Meded Proefst. Vorsteulandsche No.* **78**, 18 pp.
Watson (Hamilton), M.A. (1936). *Phil. Tran. Roy. Soc. Lond.* **B, 226**, 540, 452-489
West, J. (1936). *Trop. Agric.* (*Trinidad*), **13**, 242-44
Willie, J. (1928) *Arb. biol. Reichsanst. L and—u. Forstw.* **16**, 1, 115-167

PLATE VII

FIG. 1. Sann-hemp plant suffering from leaf-curl of S. V. 1 type

FIG. 2. Sann-hemp plant suffering from leaf-curl of S. V. 2 type

FIG. 2-*a* Leaf of the same, magnified

FIG. 3. A leaf of a typical sann-hemp plant, free from leaf-curl, magnified

FIG. 4. Sann-hemp plant in which leaf-curl was produced by experiment with diseased tobacco (*A* type) as source of infection

FIG. 4-*a* Leaf of the same, magnified

FIG. 5. A twig of *Ageratum conyzoides* suffering from leaf-curl

FIG. 5-*a* A leaf of the same, enlarged

FIG. 5-*b* A leaf from healthy twig

1
2
2a
3
4
4a
5
5a
5b

PLATE VIII

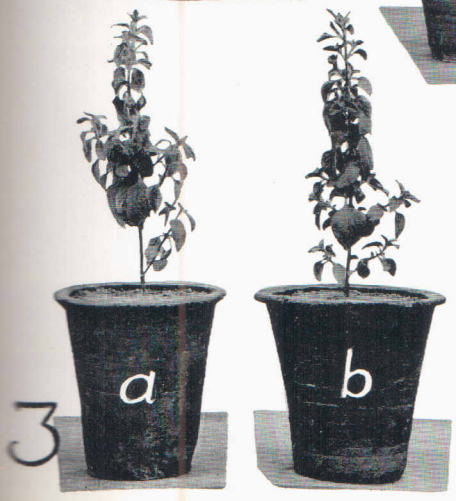
1. A series of tobacco plants (a—h) in which leaf-curl was produced by experiment with diseased sann-hemp as source of infection, j & k two typical control plants
2. Photos of some *Ageratum* plants (a—b) in which leaf-curl was produced by experiment, with diseased sann-hemp as source of infection
3. Photos of some *Ageratum* plants (a—b) in which leaf-curl was produced by experiment, with diseased *Ageratum* as source of infection ; plants c and d are controls of these as well as of the plants in Fig. 2 above
4. Photo of an *Ageratum* plant in which leaf-curl was produced by experiment, with diseased tobacco as source of infection.

1
a
b
c
d
e
f
g
h
j
k

2
a

b

4

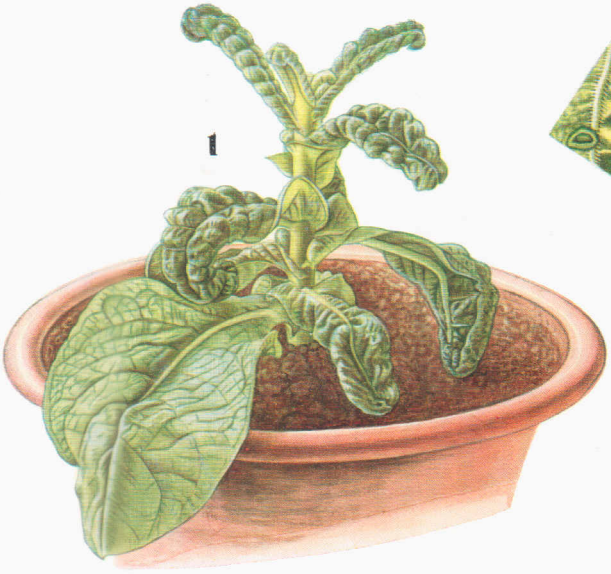

3
a
b

c

d

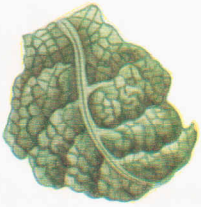
2

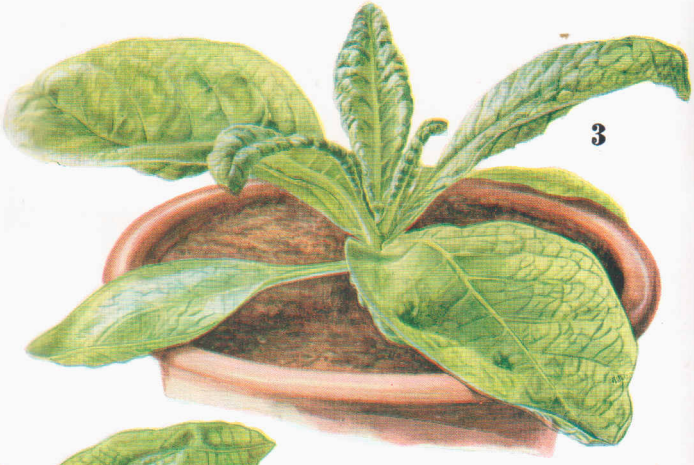
1*a*



1

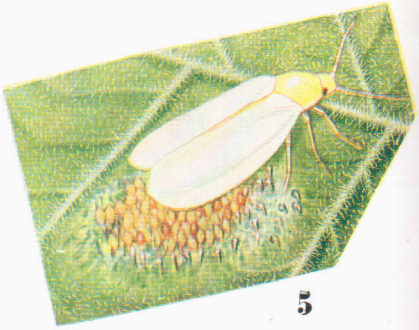
2*a*





3

4



5

TABLE IV

Yearly fluctuation in the population (expressed as percentage of parasitization) of Pyrilla *egg parasites* (O. papilionus *Ashm. and* T. pyrillae *Craw.) at Lyallpur*

Year	July	August	September	October	November	December
1926	5·7	13·9	49·3	40·9	29·7	5·8
1928	14·3	29·0	36·5	32·2	27·6	25·0
1929	..	..	13·3	24·0	24·5	9·3
1930	..	..	26·0	38·0	33·0	12·2
1931	..	19·0	27·0	52·0	79·0	36·0
1933	..	..	71·5	77·9	51·2	20·8
1934	..	28·0	46·0	47·6	42·0	..

It is seen from Table IV that the *Pyrilla* egg parasites are most active during September-November when they may parasitize 71·5 to 79 per cent of the host eggs. Table V gives the percentage of parasitization of *Pyrilla* eggs by *O. papilionus* and *T. pyrillae* Craw.

TABLE V

Percentage parasitization by the two Pyrilla *egg parasites during July-December*

Month and year	Number of eggs examined	Number of host eggs found parasitized	Parasitization percentage
July—			
1928	929	132	14·2
1932	838	254	30·4
1935	1,913	2	0·1
August—			
1934	453	127	28
1935	2,926	1	0·03
September—			
1932	5,133	2,062	40
1933	2,012	1,439	71·5
1934	3,545	1,588	44·8
1935	5,021	2,065	41

PLATE IX

1. A tobacco plant in which leaf-curl of *A* type was produced by experiment with diseased sann-hemp as source of infection

1-*a*. Lower side of a leaf of the same—note the cup-shaped enations

2 & 2*a*. Lower and upper sides of the leaves of a tobacco plant in which leaf-curl *of A type was produced using similarly diseased tobacco* plant as source of infection

3. A tobacco plant in which leaf-curl of *B* type was produced by experiment with similarly diseased tobacco plant as source of infection

4. A tobacco plant in which leaf-curl of *C* type was produced by experiment with similarly diseased tobacco plant as source of infection

5. The white-fly, *Bemisia gossypiperda*, laying eggs on a tobacco leaf

PLATE X

6. A tobacco plant in which leaf-curl of *D* type was produced by experiment with similarly diseased tobacco plant as source of infection

6-*a*. A leaf of the same, magnified

7. A tobacco plant in which leaf-curl of *X* type was produced, with a similarly affected tobacco plant as source of infection

8. A tobacco plant in which leaf-curl was produced by experiment with tobacco plants suffering from *A*, *B*, *C* and *D* types as source of infection

8-*a*. Lower surface of a leaf of the plant in FIG. 3, magnified (Note the prominent enations)

6a
6
7
8a
8

TABLE I-A

Particulars of experiments performed to transmit the disease from sann-hemp to tobacco during 1936

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series i							
Time of experiment, 6th-12th September 1936	1—3	...	6th Sept. 1936—8 A.M.	24	3—5	...	Negative.
Age of diseased sann-hemp (Source) : 8-10 weeks.	4—7	...	7th-12th Sept. 1936—8 A.M.	48	2—4	...	Do.
Age of healthy tobacco infected : about 8 weeks.							
Series ii							
Time of experiment, 20th-29th September 1936	1	...	23rd Sept. 1936—10-30 A.M.	25	5	36	Positive ; type *A*.
Age of diseased sann-hemp (Source) : 11-12 weeks.	2—4	...	20th-23rd Sept. 1936—10-30 A.M.	24—52½	2—5	...	Negative.
Age of healthy tobacco infected : 10-11 weeks.	5—8	...	28th Sept. 1936—5-45 P.M.	17¾	3—12	...	Do.
Series iii							
Time of experiment, 3rd-5th November 1936	1	...	3rd Nov. 1936—10 A.M.	24	9	19	Positive ; type *A*.
Age of diseased sann-hemp (Source) : 17 weeks.	2—6	...	4th Nov. 1936—4 P.M.	18½	11—21	...	Negative.
Age of healthy tobacco infected : 7 weeks.	7	...	Do. . .	18½	26	84	Positive ; type *X*.
	8	...	Do. . .	18½	23	74	Do.
	9	...	Do. . .	18½	17	17	Do.
		...	Do. . .	18½	18	17	Do.

TABLE I-A—*contd.*

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series iv							
Time of experiment, 3rd-4th November 1936.	1—7	...	3rd Nov. 1936—11 A.M.	24	7—17	...	Negative.
Age of diseased sann-hemp (Source) : 17 weeks.	...	...	...	...	...	...	
Age of healthy tobacco infected : 16 weeks.							
Series v							
Time of experiment, 14th December 1936	1	...	14th Dec. 1936—10 A.M.	24	6	39	Positive; type *X*.
Age of diseased sann-hemp (Source) : 22 weeks.	2	...	Do. . .	24	6	63	Positive, A type *X*.
Age of healthy tobacco infected : about 8 weeks.	3—10	...	Do. . .	24	3—7	...	Negative.

None of the controls of the various series developed leaf-curl disease.

TABLE I-B

Particulars of experiments performed to transmit the disease from sann-hemp to tobacco during 1937

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series i							
Time of experiment, 9th-11th Sept. 1937	1	S. V. I .	9th Sept. 1937—10-30 A.M.	29	14	51	Positive ; type *X*
Age of diseased sann-hemp (Source) : 13 weeks.	2	Do. . .	Do. . .	29	8	22	Positive ; type *D* ?
	3	Do. . .	Do. . .	29	7	62	Positive ; type *X*
Age of healthy tobacco infected : 8 weeks.	4	Do. .	Do. . .	29	10	28	Do.
	5	Do. . .	Do. . .	29	7	40	Do.
	6	Do. . .	Do. . .	29	8	40	Do.
	7	Do. . .	Do. . .	29	7	18	Do.
	8	Do. . .	Do. . .	29	10	18	Do.
	9	Do. . .	Do. . .	29	10	22	Positive ; type *D* ? (Recovered).
	10	Do. . .	Do. . .	29	7	22	Positive ; type *X*.
	11	Do. . .	Do. . .	29	11	18	Do.
	12	Do. . .	Do. . .	29	6	13	Do.
	13—27	Do. . .	10th Sept. 1937—4 P.M.	24	6—13	...	Negative.
	28	Do. . .	Do. . .	24	9	17	Positive; ype *X* ? (Recovered)
	29	Do. . .	Do. . .	24	11	17	Do.
	30—32	Do. . .	Do. . .	24	8—9	...	Negative.

TABLE I-B—*contd.*

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series i—contd.	33	S. V. I.	10th Sept. 1937—4 P.M.	24	7	17	Positive; type *X* (Recovered).
	34—39	Do. . .	Do. . .	24	6—14	...	Negative.
	40	Do. . .	Do. . .	24	10	32	Positive; type *X*.
Series ii							
Time of experiment, 27th September to 1st October 1937	1	S. V. 1 .	27th Sept. 1937—11 A.M.	20½	19	11	Positive; type *X*.
Age of diseased sann-hemp (Source): about 15 weeks.	2	Do . .	Do. . .	20½	21	15	Do.
	3	Do. . .	Do. . .	20½	17	11	Do.
Age of healthy tobacco infected: about 7 weeks.	4	Do. . .	Do. . .	20½	11	...	Negative.
	5	Do. . .	Do. . .	20½	9	...	Do.
	6	Do. . .	Do. . .	20½	14	15	Positive; type *X*.
	7	Do. . .	Do. . .	20½	8	11	Do.
	8	Do. . .	Do. . .	20½	11	11	Do.
	9	Do. . .	29th Sept. 1937—10 A.M.	48¾	11	12	Do.
	10	Do. . .	Do. . .	48¾	25	8	Do.
	11	Do. . .	Do. . .	48¾	22	12	Do
	12	Do. . .	Do. . .	48¾	21	11	Do.
	13	Do. . .	Do. . .	48¾	16	...	Negative.
	14	Do. . .	Do. . .	48¾	17	11	Positive type *X*.

	16	Do. . .	Do. . .	48¾	12	...	Negative.
	17	Do. . .	Do. . .	48¾	23	11	Positive ; type *X*.
	18	Do. . .	Do. . .	48¾	22	11	Do.
	19	Do. . .	Do. . .	48¾	9	...	Negative.
	20	Do. . .	Do. . .	48¾	24	11	Positive ; type *X*.
	21	Do. . .	Do. . .	48¾	23	8	Do.
	22	Do. . .	Do. .	48¾	18	14	Do.
	23	Do. . .	Do. . .	58¾	14	11	Do
	24	Do. . .	Do. .	48¾	19	12	Do.
	25	Do. . .	Do. .	48¾	26	8	Do.
	26	Do. . .	Do. . .	48¾	27	8	Do.
	27	Do. . .	Do. . .	48¾	14	25	Do.
Series iii							
Time of experiment, 27th-29th September 1937.	1	S. V. 2 .	27th Sept. 1937—11 A.M.	20½	10	11	Positive ; type *A*.
Age of diseased sann-hemp (Source): about 15 weeks.	2	Do. . .	Do. . .	20½	13	...	Negative.
Age of healthy tobacco infected : about 7 weeks.	3	Do. . .	29th Sept. 1937—10 A.M.	48¾	27	12	Positive ; type *A*.
Series iv							
Time of experiment, 31st Oct.-2nd November 1937.	1	S. V. 2 .	31st Oct. 1937—Noon.	29	25	19	Positive ; type *A*.
Age of diseased sann-hemp (Source) : 18 weeks.	2	Do. . .	Do. . .	29	5	...	Negative.
	3	Do. . .	Do. . .	29	9	13	Positive ; type *A*.
Age of healthy tobacco infected : 7 weeks.	4	Do. . .	Do. . .	29	8	19	Do.
	5	Do. . .	Do. . .	29	6	...	Negative.
	6	Do. . .	Do. . .	29	11	13	Positive ; type *A*.
	7	Do. . .	Do. . .	29	7	12	Do.

TABLE I-B—*concld.*

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection nad appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series iv—contd.	8	S. V. 2.	1st Nov. 1937—11 A.M.	24	6	...	Negative.
	9	Do. . .	Do. . .	24	16	...	Do.
	10	Do. . .	Do. . .	24	7	11	Positive ; type *A*.
	11—15	Do. .	Do. . .	24	5—16	...	Negative.
	16	Do. .	Do. .	24	10	16	Positive ; type *A*.
	17	Do. . .	Do. . .	24	7	21	Do.
	18	Do. . .	Do. . .	24	9	...	Negative.
	19—22	Do. . .	1st Nov. 1937 4 P.M.	24	11—13	11	Positive ; type *A*.
	23—25	Do. . .	Do . .	24	7—14	14—15	Do.
	26	Do. . .	Do. . .	24	11	...	Negative.
	27	Do. . .	Do. . .	24	9	...	Do.
Series v							
Time of experiment, 25th-28th November 1937.	1	S. V. 2 .	25th Nov. 1937—11 A.M.	24	6	27	Positive ; type *A*.
Age of diseased sann-hemp (Source) : 23 weeks.	2—25	Do. . .	25th-28th Nov. 1937.	24	3—7	...	Negative.
Age of healthy tobacco infected : 6 weeks.							

None of the controls of the various series developed leaf-curl disease.

TABLE II-A

Particulars of experiments performed to transmit the disease from tobacco to sann-hemp during 1936

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series i							
Time of experiment 12th-22nd September 1936	1—3	*A*	12th-14th Sept. 1936—4 P.M.	24—48	3—10	...	Negative.
Age of diseased tobacco (Source): 13—14 weeks. Age of sann-hemp inoculated: 9—10 weeks.	4—5	*C*	21st-22nd Sept. 1936—5 P.M.	24	3—5	...	Do.
Series ii							
Time of experiment: 24th Sept.—3rd Oct. 1936	1—7	*X*	24th Sept.-3rd Oct. 1936.	17—24	1—8	...	Do.
Age of diseased tobacco (Source): 13—14 weeks. Age of sann-hemp inoculated: 10—12 weeks.	8—11	*C*	29th-30th Nov. 1936—5 P.M.	24	8—12	...	Do.
Series iii.							
Time of experiment, 13th October 1936	1—3	*B*	13th Oct. 1936—9 A.M.	8	2—7	25	Slight reaction perceptible. The lower three leaves of inoculated plant were curled and drooping.
Age of diseased tobacco (Source): about 13 weeks. Age of sann-hemp inoculated: 13 weeks.	4—6	*B*	Do.	8	2—7	...	Negative.
Series iv							
Time of experiment, 5th-6th November 1936	1—8	*C*	5th-6th Nov. 1936	8—22	7—31	...	Do.
Age of diseased tobacco (Source): 17 weeks. Age of sann-hemp inoculated: 16 weeks.	9—10	*A*	Do.	22	11—13	...	Do.

None of the controls in the various series developed leaf-curl disease.

TABLE V—*contd.*

Month and year	Number of eggs examined	Number of host eggs found parasitized	Parasitization percentage
October—			
1932	2,811	1,405	50
1933	1,094	853	78·0
1934	256	119	46·4
1935	13,060	1,593	12·2
November—			
1932	3,507	2,454	70
1933	737	376	51·0
1934	256	119	46·4
1935	13,060	1,593	12·2
December—			
1932	875	429	49
1933	891	186	20·8
1935	29,443	5,257	17·9

Both these parasites are not very active during April-June and again during January-March when the percentage of parasitization is very low indeed ; of the 58,472 and 2,937,173 eggs examined during these two periods only 0·004 and 0·0006 per cent respectively were found parasitized by these two parasites.

The intensity of attack on the eggs of *Pyrilla* by the two parasites, *O. papilionus* Ashm. and *T. pyrillae* Craw., depends upon the location of the host eggs : the eggs laid exposed on the leaves are much more heavily parasitized (up to 77·9 per cent) than those laid hidden in between the leaf-sheath and the cane stem which never have more than 5 per cent parasitization.

Efficiency of Pyrilla *egg parasites in the fields.*—In order to study the efficiency of *Pyrilla* egg parasites the sugarcane crop growing in two separate blocks at the Sugarcane Research Station, Jullundur, was selected in 1935-36. The two selected blocks were about 550 ft. apart. In the beginning of August 1935, only 2 per cent of the *Pyrilla* egg-clusters were found parasitized in them.

In one block encouragement of the egg parasites was taken up while the other block was kept as control. In the treated block (about 2 acres) about 2,900 parasitized egg-clusters were placed in parasite-hibernating cages (specially designed for the purpose) which were distributed over the entire block.

Parasitization was at par (2 per cent) in both the blocks to begin with. During the fourth week of August, however, parasitization increased to 55 per cent in the block where parasites were encouraged but it was only 9 per cent in the control block.

TABLE II-B

Particulars of experiments performed to transmit the disease from tobacco to sann-hemp during 1937

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series i							
Time of experiment, 16th-17th July 1937	1—4	*A*	16th-17th July 1937	16	2—4	...	Negative.
	5—9	*X*	Do.	16	2—4	...	Do.
Age of diseased tobacco (of 1936-37 season as Source): 44 weeks.	10	*C*	Do.	16	4	...	Do.
	11	*X* of *C*	Do.	4	5	...	Do.
Age of healthy sann-hemp inoculated : 2½ weeks.	12	*C* & *D*	Do.	4	5	...	Do.
	13	*X*	Do.	6	6	117	Positive ; type S. V. I.
	14	*X*	Do.	6	6	...	Negative.
	15—16	*C*	Do.	6	6	...	Do.
	17	*A*	Do.	4	5	...	Do.
Series ii							
Time of experiment, 18th-23rd July 1937.	1	*C*	18th July 1937—8 A.M.	8	3	...	Do.
Age of diseased tobacco (1936-37 season as Source) : 36 weeks.	2	*C*	Do.	8	3	119	Positive ; type S. V. I.
	3	*C*	Do.	10	7	...	Negative.
Age of healthy sann-hemp inoculated : 2½—3 weeks.	4	*A*	Do.	8	3	...	Do.
	5	*X*	Do.	8	3	122	Positive ; type S. V. I.
	6	*X*	Do.	10	7	...	Negative.

	7	X	Do.	10	7	118	Positive; type S. V. I.
	8	X	Do.	10	7	...	Negative.
	9	A	21st July 1937—6 P.M.	13	3	...	Do.
	10	A	Do.	13	3	112	Positive ; type S. V. 2.
	11—20	A	Do.	13	3	...	Negative.
	21	C	23rd July 1937—9 A.M.	8	4	...	Do.
	22	C	Do.	8	4	...	Do.
Series iii.							
Time of experiment, 23rd-29th July 1937.	1—3	C	23rd July 1937—9 A.M.	8	4	...	Negative.
Age of diseased tobacco (1936-37 Season as Source) : 32—40 weeks.	4	C	Do.	8	4	133	Positive ; type S. V. I.
	5	C	Do.	8	4	...	Negative.
Age of healthy sann-hemp infected : 3—4 weeks.	6	C	Do.	8	4	131	Positive ; type S. V. I.
	7—12	A	24th-26th July 1937.	6—18	2—5	...	Negative.
	13—16	X	26th July 1937	6	4—5	...	Do.
	17—20	A	27th July 1937—11 A.M.	6	4—9	...	Do.
	21	D	29th July 1937—11 A.M.	7	4	...	Do.
	22	D	Do.	7	3	...	Do.
	23	D	Do.	7	3	...	Do.
	24	C	Do.	7	1	...	Do.
	25	C	Do.	7	3	117	Positive ; type S. V. I.

TABLE II-B—*contd.*

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series iv							
Time of experiment, 27th-31st August 1937.	1—2	*C*	27th Aug. 1937—5 P.M.	17	3	...	Negative.
Age of diseased tobacco (1936-37 season as Source): 49—50 weeks.	3	*C*	Do.	17	4	144	Positive ; type S. V. I.
	4	*C* & *D*	Do.	17	2	68	Do.
Age of healthy sann-hemp infected : 8—8½ weeks.	5—6	*C* & *D*	Do.	17	2—4	...	Negative.
	7	*A*	Do.	17	3	53	Positive ; type S. V. 2
	8	*A*	Do.	17	2	53	Do.
	9—10	*X*	Do.	17	2—4	...	Negative.
	11—13	*C* & *D*	28th Aug. 1937—11 A.M.	6	3—4	...	Do.
	14—16	*A*	Do.	6	3—5	...	Do.
	17	*A*	30th Aug. 1937—5 P.M.	16½	3	76	Positive ; type S. V. 2.
	18	*A*	Do.	16½	2	...	Negative.
	19	*A*	Do.	16½	4	70	Positive ; type S. V. 2.
	20	*A*	Do.	16½	2	84	Do.
	21—22	*A*	Do.	16½	3—4	...	Negative.
	23	*A*	Do.	16½	5	70	Positive ; type S. V. 2.
	24	*A*	Do.	16½	4	...	Negative.

None of the controls of the various series developed leaf-curl disease.

TABLE III-A

Particulars of experiments performed to transmit the disease from sann-hemp to sann-hemp during 1936

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series i							
Time of experiment, 8th-13th October 1936	1	...	8th Oct. 1936—5-30 P.M.	24	4	57	Positive; almost similar to the source. Side shoots also were diseased.
Age of diseased sann-hemp (Source): 14—15 weeks.	2—6	...	Do. .	24	5—9	...	Negative.
Age of healthy sann-hemp infected: 13—14 weeks.	7	...	11th Oct. 1936—2 P.M.	24	10	20	Positive; almost similar to the source. Side shoots also were diseased.
	8	...	Do. .	24	10	27	Ditto.
	9—18	...	Do. .	24	10—12	...	Negative.
	19	...	12th-13th Oct. 1936—11 A.M.	24	5	136	Positive; almost similar to the source, side shoots also were diseased.
	20—24	...	Do. .	24	5—7	...	Negative
Series ii							
Time of experiment, 4th/5th November 1936	1	...	4th-5th Nov. 1936—4 P.M.—11 A.M.	19	24	31	Positive; almost similar to the source, side shoots also were diseased.
Age of diseased sann-hemp (Source): 17 weeks.							
Age of healthy sann-hemp infected: 17 weeks.	2—10	...	Do. .	19	11—27	...	Negative.

None of the controls of the various series developed leaf-curl disease.

TABLE III-B

Particulars of experiments performed to transmit the disease from sann-hemp to sann-hemp during 1937

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series i							
Time of experiment, 2nd-3rd September 1937	1	...	2nd-3rd Sept. 1937 —NOON.	20	2	71	Positive ; type S. V. I.
Age of diseased sann-hemp (Source) : 12 weeks.	2	...	Do.	20	3	79	Ditto.
Age of healthy sann-hemp infected : 9 weeks.	3—8	...	Do.	20	2—5	...	Negative.
Series ii							
Time of experiment, and other details are same as in series *i*.	1	...	Do.	20	3	67	Positive ; type S. V. 2.
	2	...	Do.	20	3	72	Ditto.
	3—9	...	Do.	20	2—6	...	Negative.

None of the controls in the various series developed leaf-curl disease.

TABLE IV-A

Particulars of experiments performed to transmit the disease from tobacco to tobacco during 1936

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series i							
Time of experiment 14th-29th September 1936	1—6	*C*	14th-19th Sept. 1936—4 P.M.—8 A.M.	16—48	5—12	...	Negative.
Age of diseased tobacco (Source) : 14—16 weeks.	7	*C*	19th Sept. 1936—5 P.M.	48	5	39	Positive ; type *C*.
	8	*C*	Do.	48	3	...	Negative.
	9—12	*X*	18th Sep. 1936—4-30 P. M.	16	1—2	...	Do.
Age of healthy tobacco infected : 9—11 weeks.	12—13	*X*	28th Sept. 1936—5 P.M.	17	2	...	Do.
	14	*X*	Do.	17	3	31	Positive ; type *X*.
	15—17	*B*	25th Sept. 1936—4 P.M.	19	5	...	Negative.
Series ii							
Time of experiment, 8th-15th October 1936	1—7	*C*	8th-13th Oct. 1936—4 P.M.—5 P.M.	8—24	3—6	...	Negative.
Age of diseased tobacco (Source) : 12—13 weeks.	8—12	*B*	8th-10th Oct. 1936—4 P.M.—5 P.M.	24	1—7	...	Do.
Age of healthy tobacco infected : 12—13 weeks.	13	*A	15th Oct. 1936—8 A.M.	8	3	26	Positive ; type *X*. *Type A (Source) contained a little mixture of *C* & *D*.
	14—17	*A*	Do.	8—9	4—5	...	Negative.

TABLE IV-A—*contd.*

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series iii							
Time of experiment, 16th-17th Oct. 1936	1	*X*	16th Oct. 1936—9 A.M.	7½	2	25	Positive; type *X*.
Age of diseased tobacco (Source): 9 weeks.	2—3	*X*	Do.	7½	3—5	...	Negative.
Age of healthy tobacco infected: 9 weeks.		*X*	17th Oct. 1936—9 A.M.	8	5	22	Positive; type *X*.
Series iv							
Time of experiment, 28th October-6th November 1936	1	*C*	28th Oct. 1936—10 A.M.	5	10	18	Positive; type *C*.
Age of diseased tobacco (Source): 15—16 weeks.	2—14	*C*	28th Oct. and 1st Nov. 1936—10 A.M.	5—24	3—12	...	Negative.
Age of healthy tobacco infected: 6—7 weeks.	15	*C*	31st Oct. 1936—1 P.M.	24	8	22	Positive; type *C* & *D*.
	16	*C*	Do.	24	4	22	Positive; type *C*.
	17	*C*	Do.	24	7	12	Positive; type *X*.
	18—21	*C*	Do.	24	3—6	...	Negative.
	22	*C*	Do.	24	5	37	Positive; type *C*.
	23—24	*C*	Do.	24	4—8	...	Negative.
	25	*B*	28th Oct. 1936—10 A.M.	5	12	...	Do.
	26	*B*	31st Oct. 1936—1 P.M.	24	11	22	Positive; type *B*.

27—33	*B*	Do.	24	3—13	...	Negative.
34	*B*	1st Nov. 1936—3 P.M.	24	9	101	Positive ; A type *X*
35	*B*	Do.	24	11	110	Positive ; type *B*.
36	*B*	Do.	24	6	36	Positive ; *A* type *B* or *C & D*.
37	*B*	Do.	24	8	...	Negative.
38	*B*	Do.	24	7	20	Positive ; type *B*.
39	*B*	Do.	24	11	...	Negative.
40	*B*	Do.	24	9	20	Positive ; type *B*.
41	*X* of *C*	31st Oct. 1936—1 P.M.	24	4	21	Positive ; type *C & D*.
42	*X* of *C*	Do.	24	7	32	Positive ; *C* type *X*.
43	*A* with a little of *C & D*.	Do.	24	7	...	Negative.
44	Do.	Do.	24	9	22	Positive ; *C* type *X*.
45	Do.	1st Nov. 1936—3 P.M.	24	9	20	Positive ; type *X*.
46	Do.	Do.	24	13	102	Positive ; *C* type *X*.
47	Do.	Do.	24	7	...	Negative.
48	*A+B+C+D*	5th Nov. 1936—5 P.M.	21	26	140	Positive ; type *X*.
49	Do.	Do.	21	28	...	Negative.
50	Do.	Do.	21	33	102	Positive ; type *X*.
51	Do.	Do.	21	29	...	Negative. Experiment Nos. 48—51. The vectors were fed separately on diseased plants of individual types A, B, C & D and then transferred together to single healthy seedlings in each case. The result was a synthetic mixture *X*.

TABLE IV-A—*contd.*

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series v							
Time of experiment, 14th-16th December 1936	1—8	*A*	14th-16th Dec. 1936—10 A.M.—4 P.M.	6—24	3—16	...	Negative.
Age of diseased tobacco Source): 16 weeks.	9—12	*B*	14th-15th Dec. 1936—10 A.M.—4-30 P.M.	6—7	5—11	...	Do.
Age of healthy tobacco infected: about 8 weeks.	13	*B*	15th Dec. 1936—9-30 A.M.	7	7	52	Positive: type *B*.
	14—15	*B*	15th-16th Dec. 1936—9-30 A.M.—4 P. M.	6—24	3—6	...	Negative.
	16	*B*	16th Dec. 1936—10 A.M.	6	7	68	Positive; type *B*.
	17—22	*C*	14th-16th Dec. 1936—10 A.M.—9-30 A.M.	7—24	6—13	...	Negative.
	23	*C*	16th Dec. 1936—10 A.M.	6	5	59	Positive; type *C*.
	24	*C*	Do.	6	8	55	Do.
	25—33	*D*	14th-16th Dec. 1936—10 A.M.—4 P.M.	6—7	4—14	...	Negative.
Series vi							
Time of experiment, 25th December, 1936-5th January 1937.	1	*A*	25th Dec. 1936—4 P.M.	18	5	94	Positive; type not clear.
	2	*A*	Do.	18	6	31	Positive; type *A*?

Age of healthy tobacco infected : 6—8 weeks.

8—10	*A*	Do.	18	4—7	...	Negative.
11—18	*C*	Do.	18	4—9	...	Do.
19	*C*	Do.	18	6	47	Positive; type *X*.
20	*C*	Do.	18	3	...	Negative.
21	*D*	26th Dec. 1936—10 A.M.	6	5	...	Do.
22	*D*	Do.	6	4	94	Positive; type not clear.
23—30	*D*	Do.	6	4—9	...	Negative.
31	*A*+*B*+*C*+*D*	27th Dec. 1936—9 A.M.	6	11	...	Do.
32	*A*+*B*+*C*+*D*	Do.	6	13	52	Positive; type *X*.
33	*A*+*B*+*C*+*D*	Do.	6	21	87	Do.
34	*A*+*B*+*C*+*D*	Do.	6	24	...	Negative.
35	*A*+*B*+*C*+*D*	Do.	6	18	93	Positive; type *X*.
36—37	*A*+*B*+*C*+*D*	Do.	6	13—15	...	Negative.
38—39	*A* + *C*	Do.	6	11—15	...	Do.
40	*A* + *C*	Do.	6	13	36	Positive; A type *X*.
41	*A* + *D*	Do.	6	7	37	Positive; type *X*.
42	*A* + *D*	Do.	6	9	...	Negative.
43	*A* + *D*	Do.	6	11	47	Positive; type *X*.
44—45	*B*	4th-5th Jan. 1937—2 P.M.	24	2—4	...	Negative.
46	*B*	Do.	24	6	87	Positive; type not clear.
47—51	*B*	Do.	24	3—5	...	Negative.
52—56	*C*	Do.	24	3—5	...	Do.
57	*C*	Do.	24	6	31	Positive; type *C*.
58—59	*C*	Do.	24	4	...	Negative.
60—64	*X*	4th Jan. 1937—2 P.M.	24	2—6	...	Do.
65	*X*	Do.	24	8	37	Positive; type *X*.
66—67	*X*	Do.	24	4—6	...	Negative.

5. *Family Drynidae*

Lestrodrynius pyrillae Kieff.

Distribution.—It has been recorded at Gurdaspur, Jullundur, Lyallpur and Sonepat.

Insect host.—It attacks the nymphs of *Pyrilla perpusilla* Wlk.

Bionomics.—This parasite remains active throughout the year excepting during the period from January to mid-March when it is mostly present as pupae. Its extent of parasitization depends upon the age of the host nymphs : first stage nymphs are usually not much parasitized, but second and fifth stage nymphs are comparatively more, while the third and fourth stage nymphs are most heavily parasitized.

A female parasite lays up to 42 eggs. Its life-cycle occupies 37-157 days as is clear from Table VI.

TABLE VI

Duration of life-cycle of L. pyrillae *Kieff.*

Date of oviposition by the female parasite	Date of emergence of the adult parasite	Duration of life-cycle (in days)
18 April	25 May	37
27 Aug.	3 Oct.	37
27 Oct.	2 April	157
29 Nov.	6 April	128
8 Dec.	10 April	123

The percentage of parasitization by this parasite was studied during 1930-36 when more than 42-5 thousands of nymphs were examined. (Each parasitized nymph was found to have 1-3 Drynid sacs.) The results for January-June 1931 and July-December 1930 only are presented in Table VII.

TABLE VII

Percentage of parasitization of the nymphs of Pyrilla by L. pyrillae *during different months of the year*

Time of the year	Locality	Percentage parasitization of *Pyrilla* nymphs
January . .	Jullundur .	0·2
	Lyallpur .	1·2
February .	Jullundur .	0·2
	Lyallpur .	0·3
March . .	Jullundur .	0·2
	Lyallpur .	0·2

TABLE IV-A—*concld.*

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series vii							
Time of experiment, 6th-9th February 1937	1	*A*	6th Feb. 1937—3 P.M.	18	9	17	Positive ; type *X*.
	2—15	*A*	Do.	18	4—11	17	Negative.
Age of diseased tobacco (Source) : 22 weeks.	16—19	*B*	Do.	18	5—12	17	Do.
Age of healthy tobacco infected : about 7 weeks.	20	*B*	Do.	18	8	37	Positive ; type *B*.
	21—24	*B*	Do.	18	6—9	...	Negative.
	25	*B*	Do.	18	7	18	Positive ; type *B*.
	26—27	*B*	Do.	18	9	...	Negative.
	28	*B*	Do.	18	8	19	Positive ; type *B*.
	29	*B*	Do.	18	9	26	Do.
	30	*B*	Do.	18	9	...	Negative.
	31—45	*C*	Do.	18	5—13	...	Do.
	46—50	*D*	Do.	18	7—11	...	Do.

51	*D*	Do. .	18	7	20	Positive ; type not clear.
52	*D*	Do. .	18	6	24	Do.
53	*D*	Do. .	18	4	...	Negative.
54	*D*	Do. .	18	9	20	Positive ; type *X*
55	*D*	Do. .	18	6	...	Negative.
56	*D*	Do. .	18	6	22	Positive ; type not clear.
57—63	*D*	Do.	18	7—11	...	Negative.
64	*D*	Do. .	18	8	34	Positive ; type not clear.
65	*D*	Do. .	18	6	...	Negative.
66	*X*	7th Feb. 1937—2 P.M.	24	6	19	Positive ; type *X*.
67	*X*	Do. .	24	7	...	Negative.
68	*X*	Do. .	24	4	23	Positive ; type *X*.
69	*X*	Do. .	24	9	...	Negative.
70	*X*	Do. .	24	8	25	Positive ; type *X*.
71—73	*X*	Do. .	24	5—9	...	Negative.
74	*X*	Do. .	24	7	20	Positive ; type *X*.
75—77	*X*	Do. .	24	5—7	...	Negative
78—79	*X*	8th-9th Feb. 1937—2 P.M.	24	6—7	...	Do.
80	*X*	Do. .	24	5	11	Positive ; type *X*.

None of the controls of the various series developed leaf-curl disease.

TABLE IV-B

Particulars of Experiments performed to transmit the disease from tobacco to tobacco during 1937

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2		4	5	6	7	8
				(Hours)		(Days)	
Series i							
Time of experiment, 14th-15th October 1937	1	*D*	14th Oct. 1937—9 A.M.	7	4	34	Positive; type *X*.
Age of diseased tobacco (Source): 13 weeks.	2	*D*	Do.	7	5	32	Do.
Age of healthy tocacco infected: about 9 weeks.	3—17	*D*	Do.	7—24	4—9	...	Negative.
	18—20	*X*	14th-15th Oct.1937—9 A.M.	24	4—6	...	Do.
Series ii							
Time of experiment, 5th-9th November 1937	1—2	*A*	5th Nov. 1937—4 P.M.	24	4—5	...	Do.
Age of diseased tobacco (Source): 10 weeks.	3—6	*D*	Do.	18—24	5—10	...	Do.
Age of healthy tobacco infected: 8 weeks.	7—8	*X*	Do.	18—24	1—8	...	Do.
	9—10	*A* type *X*	Do.	18—24	5—7	...	Do.
	11—15	*A* & *C*	Do.	24	1—9	...	Do.

	16—18	*A & C*	6th November 1937—3-30 P.M.	17½	5—10	...	Do.
	19—21	*B*	Do.	17½	2—5	...	Do.
	22	*C*	Do.	17½	6	30	Positive; type trace of C. recovered.
	23—30	*C*	Do.	17½	2—10	...	Negative.
	31	*C*	8th-9th November 1937—11-15 A.M.	24	12	25	Positive; *C* type *X*.
	32	*C*	Do.	24	3	...	Negative.
	33—35	*B*	Do.	24	2—5	...	Do.
Series iii.							
Time of experiment, 29th November-1st December 1937	1—6	*C*	29th November 1937—NOON.	24	2—8	...	Do.
Age of diseased tobacco (Source): 13 weeks.	7—9	*B*	Do.	24	1—5		Do.
Age of healthy tobacco infected: 7 weeks.	10—13	*A*	Do.	24	2—4	...	Do.
	14 15	*X*	Do.	24	2—3	...	Do.
	16—21	*D*	29th November 1937—4 P.M.	24	1—5	...	Do.
	22—23	*X*	30th November-1st December 1937—4 P.M.	24	8—9	...	Do.
	24—25	*C*	Do.	24	5—6	...	Do.

None of the controls of the various series developed leaf-curl disease.

TABLE V

Particulars of Experiments performed to transmit the disease from Ageratum conyzoides *to tobacco during 1936 and 1937*

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series i							
Time of experiment, 16th-17th December 1936	1	...	16th-17th December 1936—3 P.M.	25	16	34	Positive; type *D.*
Age of diseased *Ageratum* (Source): not known, obtained from field.	2	...	Do.	25	6	33	Do.
Age of healthy tobacco infected, 9 weeks.	3—6	...	Do.	25	6—11	...	Negative.
Time of experiment, 5th-8th September 1937	1	...	5th Sept. 1937—2 P.M.	25	3	55	Positive; type *D.*
Age of diseased *Ageratum* (Source): not known, obtained from field.	2—6	...	Do.	25	2—4	...	Negative.
Age of healthy tocacco infected, 8 weeks.	7	...	6th Sept. 1937—11 A.M.	21	4	...	Do.
	8	...	Do.	21	9	16	Positive; type *D.*
	9—12	...	Do.	21	3—5	...	Negative.
	13	...	Do.	21	7	54	Positive; type *D.*
	14	...	Do.	21	4	54	Do.
	15	...	Do.	21	3	15	Do.
	16	...	Do.	21	7	25	Do.
	17—19	...	Do.	21	5—7	...	Negative.
	20	...	Do.	21	3	49	Positive; type *D.*
	21	...	7th Sept. 1937—5 P.M.	16	7	24	Do.

		...	Do.	16	8	...	Negative.
	23	...	Do.	16	10	53	Positive; type *D*
	24	...	Do.	16	14	...	Negative.
	25	...	7th-8th Sept. 1937—5 P.M.	16	13	15	Positive; type *D*
	26	...	Do.	16	5	24	Do.
	27	...	Do.	16	14	14	Do.
	28	...	Do.	16	16	66	Do.
	29	...	Do.	16	8	13	Do.
	30	...	Do.	16	11	83	Do.
	31	...	Do.	16	12	...	Negative.
	32	...	Do.	16	8	24	Positive; type *D*.
	33	...	Do.	16	5	66	Positive; *D* type *X*.
	34	...	Do.	16	12	53	Positive; type *D*.
	35	...	Do.	16	10	35	Do.
	36	...	Do.	16	7	24	Positive; type *D* ? (Recovered).
	37	...	Do.	16	9	65	Positive: type *D*.
	38	...	Do.	16	7	68	Do.
	39	...	Do.	16	7	64	Do.
	40	...	Do.	16	9	66	Do.
Series ii							
Time of experiment, 26-28th September 1937 Age of diseased *Ageratum* (Source): not known, obtained from field. Age of healthy tobacco infected: 6 weeks.	1—3	...	26th Sept. 1937—10 A.M.	25	7—11	...	Negative.
	4	...	Do.	25	6	15	Positive; type *D*.
	5	...	Do.	25	11	15	Do.
	6—7	...	Do.	25	7—8	...	Negative.
	8	...	Do.	25	9	23	Positive; type *D*.
	9—10	...	Do.	25	6—8	...	Negative.
	11	...	Do.	25	12	30	Positive; type *D*.
	12—15	...	Do.	25	8—13	...	Negative.
	16	...	Do.	25	9	15	Positive; type *D*.

TABLE V—*contd.*

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series ii—contd.							
	17	...	26th Sept. 1937—10 A.M.	25	11	...	Negative.
	18	...	Do. .	25	6	27	Positive ; type *D*.
	19—20	...	Do. .	25	7—11	...	Negative.
	21	...	27th-28th Sept. 1937—11 A.M.—7-30 A.M.	20½	10	24	Positive ; type *D*.
	22—24	...	Do. .	20½	13—21	...	Negative.
	25	...	Do. .	20½	24	11	Positive ; *D* type *X*.
	26—30	...	Do. .	20½	14—26	...	Negative.
Series iii'							
Time of experiment, 2nd-5th November 1937.	1	...	2nd Nov. 1937—4 P.M.	44	6	24	Positive ; type *D*.
	2—7	...	Do. .	44	5—8	...	Negative.
Age of diseased *Ageratum* (Source) : 13 weeks.	8—14	...	4th-5th Nov. 1937.—NOON.	29	6—12	...	Do.
Age of healthy tobacco infected : 7 weeks.	15	...	Do. .	29	10	33	Positive ; type *D*.
	16—17	...	Do. .	29	6—8	...	Negative

	18	...	Do. .	29	9	31	Positive ; type *D*.
	19	...	Do. .	24	9	...	Negative.
	20	...	Do. .	24	13	27	Positive ; type *D*
Series iv							
Time of experiment, 22nd-26th November 1937.	1—2	...	22nd Nov. 1937—NOON.	24	4—7	...	ve.
Age of diseased *Ageratum* (Source) : 16 weeks.	3	...	Do. .	24	8	41	Positive ; type *D*.
	4		Do. .	24	1	19	Do.
Age of healthy tobacco infected : 6 weeks.	5	...	Do. .	24	3	32	Positive ; type *D* (Recovered).
	6	...	Do. .	24	5	19	Positive ; type *D*.
	7	...	Do. .	24	1	19	Do.
	8	...	Do. .	24	5	30	Do.
	9	...	Do. .	24	5	19	Do.
	10	...	22nd Nov. 1937—4 P.M.	24	1	...	Negative.
	11	...	Do. .	24	5	22	Positive ; type *D* ? (Recovered).
	12	...	Do. .	24	6	19	Positive ; type *D*.
	13	...	Do. .	24	4	19	Do.
	14	...	23rd Nov. 1937—4 P.M.	24	2	...	Negative.
	15	...	Do. .	24	4	49	Positive ; type *D*.
	16—18	...	Do. .	24	4—7	...	Negative.
	19	...	Do. .	24	4	26	Positive : type *D*.
	20	...	Do. .	24	5	28	Do.
	21	...	24th—26th Nov. 1937—3 P.M.—9 A.M.	42	3	...	Negative.
	22	...	Do. .	42	4	26	Positive ; type *D*.
	23—30	...	Do. .	42	2—6	...	Negative.

None of the controls of the various series developed leaf-curl disease.

TABLE VI

Particulars of Experiments performed to transmit the disease from tobacco to Ageratum conyzoides *during 1937*

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series i							
Time of experiment, 29th-30th October 1937.	1—9	D	29th-30th Oct. 1937—5 P.M.—9 A.M.	16	2—9	15—47 average.	Positive; type resembled that occurred in nature. Profuse branching resulted.
Age of diseased tobacco (Source): 9 weeks.	...	...	...	...	...	35	
Age of healthy *Ageratum* infected: 11 weeks.							

None of the controls of the series developed leaf-curl disease.

TABLE VII

Particulars of Experiments performed to transmit the disease from Ageratum conyzoides *to sann-hemp during 1937*

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series v							
Time of experiment, 2nd-5th Sept. 1937.	1	...	3rd Sept. 1937—11 A.M.	23	3	78	Positive; type S. V. 2 Side shoots also diseased.
Age of diseased *Ageratum* (Source): 11 weeks.	2—5	...	2nd-4th Sept. 1937—NOON—10 A.M.	20—23	2	...	Negative.
Age of healthy sann-hemp infected: 9 weeks.	6—13	...	3rd-5th Sept. 1937—4 P.M.—10 A.M.	18—23	2—7	...	Do.
	14	...	4th Sept. 1937—10 A.M.	18	5	72	Positive; type S. V. 2.
	15—18	...	Do.	18	2—4	...	Negative.

None of the controls of this series developed leaf-curl disease.

TABLE VII—*contd.*

Time of the year	Locality	Percentage parasitization of *Pyrilla* nymphs
April . . .	Jullundur .	0·2
	Lyallpur .	0·2
May . .	Jullundur .	0·2
	Lyallpur .	0·6
June . .	Jullundur .	0·2
	Lyallpur .	3·5
July . .	Jullundur .	1·5
	Lyallpur .	1·5
August . .	Jullundur .	1·6
	Lyallpur .	0·8
September .	Jullundur .	1·9
	Lyallpur .	2·1
October . .	Jullundur .	2·5
	Lyallpur .	3·2
November .	Jullundur .	3·1
	Lyallpur .	3·1
December .	Jullundur .	0·5
	Lyallpur .	0·2

It is seen from Table VII that though the parasite is present throughout the year, it is abundant during September-November only.

L. pyrillae Kieff. is hyperparasitized by *Cheiloneurus* sp. (Fam. Encyrtidae) which is usually active during November-March.

ORDER STREPSIPTERA

Pyrilloxenos compactus Pierce

Distribution.—This parasite was recorded in the Punjab for the first time in 1928. Subsequently it was found to be fairly abundant throughout the sugarcane-growing areas of the Punjab and has been actually collected from Gurdaspur, Jullundur, Lyallpur and Sonepat.

Insect hosts.—It parasitizes the nymphs and adults of *Pyrilla perpusilla* Wlk., but shows a decided preference for the adults.

Bionomics.—It is a parasite of sporadic occurrence. During the period (1928 to date) it has been under study it occurred in abundance in 1934 at Lyallpur and in 1935 at Sonepat while in other years it was scarce throughout the province.

TABLE VIII

Particulars of Experiments performed to transmit the disease from sann-hemp to Ageratum conyzoides *during 1937*

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series i							
Time of experiment, 11th-12th Oct. 1937.	1	S. V. 1.	11th-12th Oct. 1937—3 P.M.	24	9	...	Negative.
Age of diseased sann-hemp (Source): 11 weeks.	2—10	S. V. 1	Do.	24	5—12	49—69 average. 59	Positive; type resembled that occurred in nature.
Age of healthy *Ageratum* infected : 11 weeks.	...	...	...	...	...	...	Profuse branching resulted.
Series ii							
	1—11	S. V. 2	11th-12th Oct. 1937—3 P.M.	24	5—11	38—100 Average. 63	Positive; type resembled that occurred in nature. Profuse branching resulted.

None of the controls of this series developed leaf-curl disease.

TABLE IX

Particulars of Experiments performed to transmit the disease from Ageratum conyzoides *to* Ageratum Conyzoides *during 1937*

Series	No. of experiment	Type of disease used as source	Date of putting white-flies on the diseased plant	Period for which the specimens remained on the diseased plant	No. of specimens transferred to healthy plant	Period between the time of infection and appearance of disease	Results and remarks
1	2	3	4	5	6	7	8
				(Hours)		(Days)	
Series i.							
Time of experiment, 10th-11th October 1937 and 29th-31st October 1937.	1—19	...	10th-11th Oct. 1937—11 A.M.	24	5—11	13—71 average 42.	Positive; type resembled that occurred in nature. Profuse branching resulted.
Age of diseased *Ageratum* (Source) : 14 weeks	20	...	Do.	24	9	...	Negative.
Age of healthy *Ageratum* infected : 11 weeks.	21—24	...	29th-31st Oct. 1937—5 P.M.	22—24	6—10	27—39 average 34.	Positive; type resembled that occurred in nature Profuse branching resulted.

None of the controls of this series developed leaf-curl disease.

GIPD—S 3—646 IC of AR—31-5-39—88.

Bulletin No. 132

Agricultural Research Institute, Pusa

Report of Campaign against *Spodoptera mauritia*, Boisd., (*Noctuidae*), in Malabar

BY

E. BALLARD, B.A., F.E.S.,
Government Entomologist, Madras.

(*Reprinted from the Proceedings of the Fourth Entomological Meeting*)

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1922

Price, As. 2.

Edited by

The Council of the Pusa Agricultural Research Institute which is not, as a body, responsible for the opinions expressed in the Bulletin.

Bulletin No. 132 1922

Agricultural Research Institute, Pusa

Report of Campaign against *Spodoptera mauritia*, Boisd., (*Noctuidae*), in Malabar

BY

E. BALLARD, B.A., F.E.S.,
Government Entomologist, Madras.

(Reprinted from the Proceedings of the Fourth Entomological Meeting)

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1922

Agents for the Sale of Books Published by the Superintendent of Government Printing, India, Calcutta.

IN EUROPE.

Constable & Co., 10, Orange Street, Leicester Square, London, W.C.

Kegan Paul, Trench, Trübner & Co., 68-74, Carter Lane, E.C., and 39, New Oxford Street, London, W.C.

Bernard Quaritch, 11, Grafton Street, New Bond Street, London, W.

P. S. King & Sons, 2 & 4, Great Smith Street, Westminster, London, S.W.

H. S. King & Co., 65, Cornhill, E.C., and 9, Pall Mall, London, W.

Grindlay & Co., 54, Parliament Street, London, S.W.

Luzac & Co., 46, Great Russell Street, London, W.C.

W. Thacker & Co., 2, Creed Lane, London, E.C.

T. Fisher Unwin, Ltd., 1, Adelphi Terrace, London, W.C.

Wheldon & Wesley, Ltd., 28, Essex Street, London, W.C.

B. H. Blackwell, 50 & 51, Broad Street, Oxford.

Deighton Bell & Co., Ltd., Cambridge.

Oliver and Boyd, Tweeddale Court, Edinburgh.

E. Ponsonby, Ltd., 116, Grafton Street, Dublin.

Ernest Leroux, 28, Rue Bonaparte, Paris.

Martinus Nijhoff, The Hague, Holland.

Otto Harrassowitz, Leipzig.

Friedländer and Sohn, Berlin.

IN INDIA AND CEYLON.

Thacker, Spink & Co., Calcutta and Simla.

Newman & Co., Calcutta.

R. Cambray & Co., Calcutta.

S. K. Lahiri & Co., Calcutta.

B. Banerjee & Co., Calcutta.

The Indian School Supply Depôt, 309, Bow Bazar Street, Calcutta, and 226, Nawabpur, Dacca.

Butterworth & Co. (India), Ltd., Calcutta.

Rai M. C. Sarcar Bahadur & Sons, 90/2A, Harrison Road, Calcutta.

The Weldon Library, 57, Park Street, West, Calcutta.

Standard Literature Co., Ltd., Calcutta.

Lall Chand & Sons, Calcutta.

Association Press, Calcutta.

Higginbotham & Co., Madras.

V. Kalyanarama Iyer & Co., Madras.

G. A. Natesan & Co., Madras.

S. Murthy & Co., Madras.

Thompson & Co., Madras.

Temple & Co., Madras.

P. R. Rama Iyer & Co., Madras.

Vas & Co., Madras.

E. M. Gopalakrishna Kone, Madura.

Thacker & Co., Ltd., Bombay.

D. B. Taraporevala, Sons & Co., Bombay.

Radhabai Atmaram Sagoon, Bombay.

Sunder Pandurang, Bombay.

Gopal Narayan & Co., Bombay.

Ram Chandra Govind & Son, Kalbadevi, Bombay.

Proprietor, New Kitabkhana, Poona.

The Standard Bookstall, Karachi.

Mangaldas Harkisandas, Surat.

Karsandas Narandas & Sons, Surat.

A. H. Wheeler & Co., Allahabad, Calcutta and Bombay.

N. B. Mathur, Supt., Nazir Kanun Hind Press, Allahabad.

Munshi Seeta Ram, Managing Proprietor, Indian Army Book Depôt, Juhi, Cawnpore.

Rai Sahib M. Gulab Singh & Sons, Mufid-i-Am Press, Lahore and Allababad.

Rama Krishna & Sons, Lahore.

Supt., American Baptist Mission Press, Rangoon.

Proprietor, Rangoon Times Press Rangoon.

Manager, the "Hitavada," Nagpur.

S. C. Talukdar, Proprietor, Students and Company, Cooch Behar.

A. M. & J. Ferguson, Ceylon.

Manager, Educational Book Depôts, Nagpur and Jubbulpore.*

Manager of the Imperial Book Depôt, 63, Chandney Chauk Street, Delhi.*

Manager, "The Agra Medical Hall and Co-operative Association, Ltd." (Successors to A. John & Co., Agra).*

Supt., Basel Mission Book and Tract Depository, Mangalore.*

P. Varadachary & Co., Madras.*

D. C. Anand & Sons, Peshawar.*

Ram Dayal Agarwala, 184, Katra, Allahabad.*

Manager, Newal Kishore Press, Lucknow.*

Maung Lu Gale, Proprietor, Law Book Depôt, Mandalay.

* Agents for the Sale of Legislative Department publications only.

8.—REPORT OF CAMPAIGN AGAINST *SPODOPTERA MAURITIA*, BOISD. (*NOCTUIDÆ*), IN MALABAR.

(Plates VIII—XII.)

By E. BALLARD, B.A., F.E.S., *Government Entomologist, Madras.*

Spodoptera mauritia, Boisd., is one of the most serious pests of paddy * in Malabar. Its appearances are erratic but always fatal unless timely precautions are taken in dealing with it. In some cases during a heavy attack the caterpillars are in such numbers as to cover the roads and *bands* and they even invade the gardens. The main fact of its lifehistory, egg and pupal periods and so forth are well known, but there is a very large number of questions which still remain unanswered. With a little organization its control when it appears in pest conditions is comparatively easy, but unfortunately it is seldom noticed by the *raiyats* until the larvæ are more than half grown by which time the damage done is serious, often necessitating either the resowing of the crop or the purchase of seedlings from unattacked areas. Up to the present year it had been the custom to await reports of the appearance of the pest from Tahsildars or *raiyats* and then to send an officer to demonstrate control measures. Although information was often (and in 1919 almost invariably) given by wire, a great deal of damage had generally been done before the officer could get to the spot. Leaflets explaining the methods of controlling the insect and its habits had been issued to the revenue authorities but it is only in very exceptional cases that these leaflets ever reach the *raiyat*. They either disappear into the Taluq offices or else remain with the village officials carefully filed. My return to India in May 1919 coincided with a very fierce and widely spread *Spodoptera* attack, but little could be done to deal with it at that time. It was decided therefore to be thoroughly prepared for the pest this year (1920) and for this purpose a programme of propaganda and extension lectures was drawn up and put into operation.

Before giving an account of the plan of campaign and the extent to which we were able to conduct it "according to plan" it would be as well to give some short account of the lifehistory and habits of *Spodoptera mauritia* itself. (Plate IX.)

"The eggs are deposited usually on the under-surface of blades of grass or paddy in batches covered with buff-covered hairs derived from

* *Oryza sativa.*

the body of the female moth. The full-grown caterpillar is 35-40 mm. long, cylindrical, paler or darker green above, greenish yellow beneath, with a reddish stripe along the sides at the junction of the two lines; along the side there is sometimes a broad pale stripe edged above by black lunules on each segment; when touched the caterpillar curls up until the head and tail are nearly touching in a characteristic manner.

"When full fed it pupates in the soil, turning into a brownish pupa, from which the moth emerges in ten days."*

The larva is essentially a night feeder, but in districts which are permanently under water it feeds by day, or remains clinging to the blades of the paddy; and it is in such situations that its control is most easily effected.

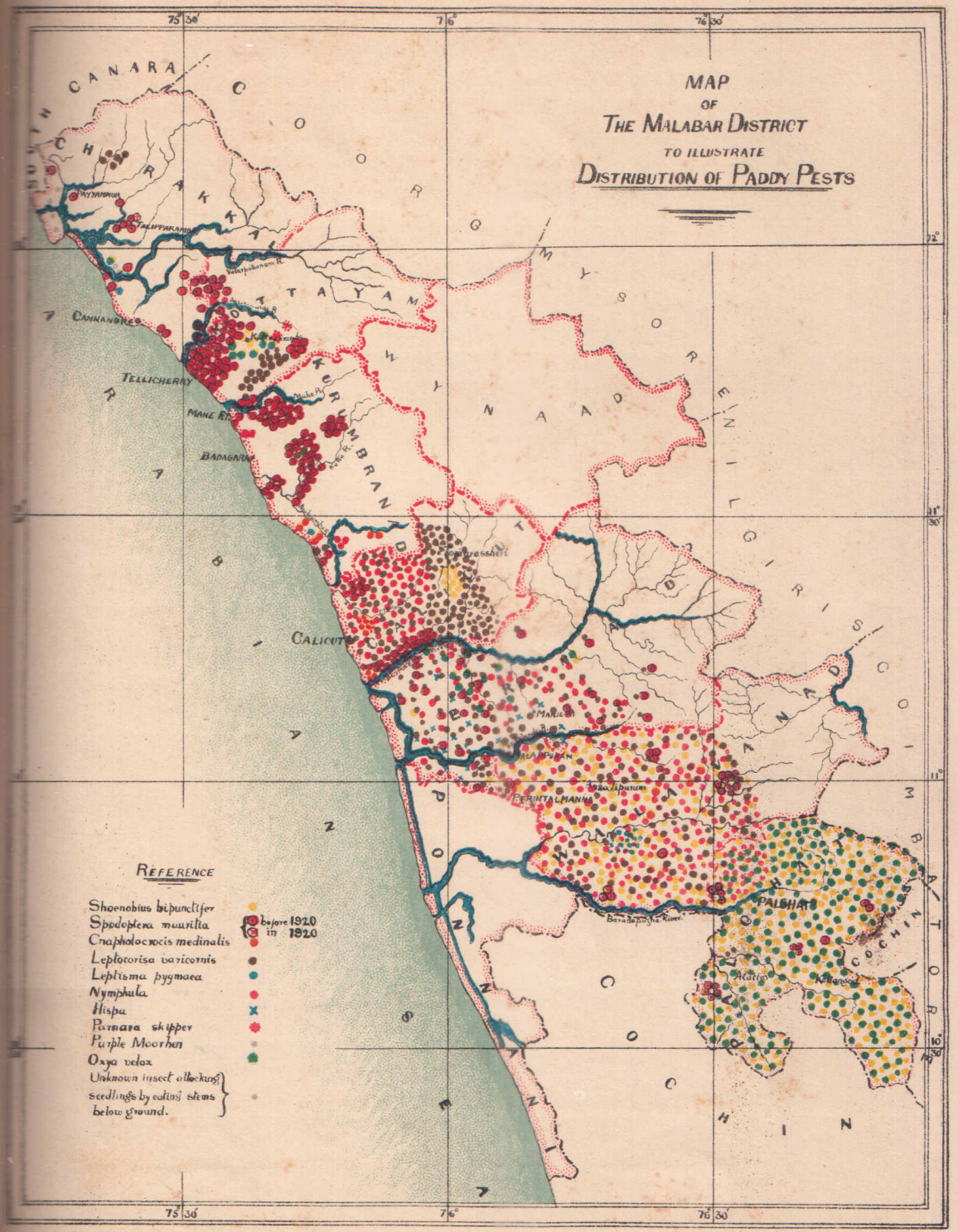
The appearance of an attacked paddy plot is very characteristic and gives the impression of having been grazed by cattle; in fact, the writer has more than once gone to a seed bed to look for *Spodoptera* in tracts where it was in pest conditions only to find that stray cattle were responsible for the seedlings in that particular plot being eaten down, although at a short distance a *Spodoptera*-attacked plot bore the same aspect.

So far as our experience in Malabar goes, it would seem that in that district there is only one generation in the year, although it is possible that in one or two places, and then only exceptionally, a few moths may come out a month earlier than is usual.

The first and only emergence appears to take place in May † and it is this generation which is the pest generation. It was believed that there was a preliminary small emergence in March or April, but all searches for moths or caterpillars were fruitless and it is very doubtful whether any generation precedes the one in May. Except in a very few places there would be no food for the larvæ before this time as the whole country is dried up. By the beginning of May most of the paddy has been sown. In Malabar this paddy starts as a dry crop and the *raiyat* is dependent on the South-west monsoon for it to reach maturity. There is no tank irrigation, and most of the paddy is either sown broad-cast or in lines behind a plough. Transplantation, where it occurs, is done after the monsoon has burst and the fields are flooded. Once the monsoon has burst and burst well, there is no more trouble from *Spodoptera* as the fields fill up so rapidly and the rain descends with such force that the larvæ are drowned and carried away. They may also be driven to the tops of the paddy blades and devoured by birds. If the monsoon is late,

* Fletcher, *Some South Indian Insects*, p. 378.

† Unless the contrary is stated all remarks on the habits of *Spodoptera mauritia* only apply to Malabar district.


MAP
OF
THE MALABAR DISTRICT
TO ILLUSTRATE
DISTRIBUTION OF PADDY PESTS
CANARA
COORG
MYSORE
NILGIRIS
COCHIN
CANNANORE
TELLICHERRY
BADAGARA
CALICUT
PALGHAT
Ponnani R.
Kadalundi R.
Beypore R.
Kallayi R.
Korapuzha R.
Valapattanam R.
Kuppam R.
Mahe R.
Kotta R.
Chaliyam R.
Kadvayar R.
Kalpetta
Manantoddy
Mananthavadi
Tirunelli
Perintalmanna
Ottapalam
Pattambi
Kollengode
Alattur
Kalpathi
Chittur
Parambikulam
Anamalai
Valparai
Kodumudi
Erode
Bhavani
Coimbatore
Pollachi
Palni
Dindigul
Karur
Trichinopoly
Tanjore
Negapatam
Shoranur
Cochin
Trichur
Chalakudi
Ernakulam
Alleppey
Quilon
Trivandrum
Cape Comorin
Tuticorin
Tinnevelly
Palamcottah
Ambasamudram
Tenkasi
Courtallam
Shencottah
Aryankavu
Talipparamba
Cheruvannur
Kottayam
Nedumangad
Attingal
Varkala
Trivandrum
Kayamkulam
Mavelikara
Tiruvalla
Changanacheri
Pathanamthitta
Kottarakara
Punalur
Shencottah
Tenmalai
Ambasamudram
Palamcottah
Tinnevelly
Tuticorin
Cape Comorin
Quilon
Alleppey
Ernakulam
Trichur
Shoranur
Pollachi
Coimbatore
Palni
Dindigul
Karur
Trichinopoly
Tanjore
Negapatam
Bhavani
Erode
Kodumudi
Parambikulam
Anamalai
Valparai
Chittur
Kollengode
Ottapalam
Pattambi
Perintalmanna
Tirunelli
Manantoddy
Mananthavadi
Kalpetta

(3) The final phase of the campaign was to consist of a prompt reply to all demands for aid, and a personal demonstration of the methods which had been advised.

The Revenue Authorities were asked to help ; the Educational Department was provided with lantern slides and a short account of the pest so that lectures could be given in schools. School-masters were to be instructed to get into touch with the officer lecturing in the *taluq* in which his school was situated so that should the pest appear school-children could be shown it in the fields and the opportunity given of at least one piece of nature study. Lastly the co-operative societies which were very strong in one *taluq* * were to be asked to help to gather *raiyats* together and to read leaflets and posters.

The control methods which were advocated and which have given satisfactory results in the past were as follows :—

(1) On the appearance of the caterpillar the first thing to do is to isolate the attacked area by digging steep-sided trenches around it. The caterpillars as they migrate fall into these trenches and are unable to climb out. They can then be easily crushed and killed. In the meantime the caterpillars in the attacked areas can be collected in winnowing fans and bags and destroyed.

(2) Where water is available the attacked areas can be flooded and the caterpillars driven to the tops of the blades of paddy from which they can be either knocked off and drowned by dragging a rope or bamboo across, or they can be collected by hand. In this case also they are much exposed to the attacks of birds, who are always of great assistance.

If the rope method is used, water should be drained off after the caterpillars have been knocked from the plants as, if fairly old, they can climb up the stems again. Young caterpillars are easily drowned.

(3) After an attack by *Spodoptera*, *bands* should be scraped and pupæ exposed or destroyed.

(4) It is the custom in some parts of Malabar to scatter rice on the *bands* when *Spodoptera* has appeared, in order to attract the birds.

(5) Before there is any water in the fields a close watch is to be kept on broad-cast paddy and on seed-beds.

(6) Provision of perches for birds in the fields.

(7) Isolation of seed beds by trenches.

This was the ideal. How far the realization fell short of it will now be shown.

With the exception of one *taluq* (Calicut) all lectures began according to programme on the 1st of March. The preliminary press adver-

* Walluvanad.

tising had been well done and in theory knowledge that the lectures were going to be held should have been fairly widespread. It was hoped that some discussion would have been excited and that some *raiyats* at least would be anxious to turn up to the lectures and find out what they were all about.

In actual practice the advance advertising was a failure. Little, if any, advance information had filtered down to the actual cultivators and those who had seen the newspapers did not appear to have attached any serious meaning to the enclosed slips.

Some *raiyats* had heard that an officer was coming to talk to them but complained that they had so often been told that some official or other was coming to their village who, after preparation to receive him, had not come, and that they had taken no notice of any leaflet or poster that they had seen.

Again, owing to a variety of causes the coloured posters did not arrive until it was too late to use them. Printed posters had been issued to the *Tahsildars* who had forwarded a few to *Adhikaris* * who had taken no action. In one *taluq* only, where the co-operative societies were called in to aid us, had the posters been stuck up in prominent places as had been previously arranged.

What actually happened was that arrangements were made with the *Adhikari* the day previous to any lecture and he was responsible for gathering his *raiyats* at the chosen spot. These arrangements had usually to be made in person by the lecturer. *Adhikaris* differed very much in the amount of enthusiasm which they showed.

Some meetings were very well attended, others consisted of two or three *raiyats* only. Taking the lecturing part of the programme as a whole, the size of the audiences was disappointing.† I had hoped to provide each lecturer with a magic lantern but only four could be procured, one of which was kindly lent by the Publicity Bureau, and these generally gathered better crowds than a lecture which was not illustrated by lantern slides. The interest displayed in the lectures themselves varied very much with the part of the district in which they were given. In some parts also the knowledge of the pests was quite good, derived not from leaflets or pamphlets but from observation. The poorest audiences from point of view of numbers, were obtained in Calicut and Ernad *taluqs*. The latter *taluq* is the greatest Moplah stronghold and most *raiyats* refused to be convinced that their usual method of dealing with insect pests, namely, of paying Rs. 100 to the local priest and getting

---

* Amsam (village) head-man.
† Number varied from 5 to 300.

The parasite remains active throughout the year. Table VIII gives the duration of the life-cycle of the male.

TABLE VIII

Duration of the life-cycle of the male P. compactus *Pierce*

Triungulinid hibernated in host	Adult male emerged	Duration of life-cycle (in days)
16 May	27-29 June	42—44
27 Sept.	5 Nov.	39

The parasite has about five generations in a year as follows : February, May, May-July, July-September, September-November, November-February.

Table IX gives the percentage of parasitization in 1934 at Lyallpur and in 1935 at Sonepat.

TABLE IX

Percentage of parasitization of P. perpusilla *adults and nymphs by* P. compactus *Pierce*

(Total number of nymphs examined—1977; total number of adults examined—791)

Period		Locality	Nymphs	Adults
May	1934	Lyallpur	..	28·9
June	,,	,,	14·2	..
July	,,	,,	71·0	18
August	,,	,,	18—32	11·49
November	,,	,,	9	22
December	,,	,,	0·5	7
February	1935	Sonepat	11	10
March	,,	,,	88	50
April	,,	,,	86	37
May	,,	,,	10	37
June	,,	,,	12	66
July	,,	,,	35	..
August-November	1935	,,	0·07—2·6	1·1—2·3

from him a flag to wave over the fields, was not infinitely better than anything suggested to them by an officer who was not one of the revenue officers and therefore of no account. In Calicut *taluq* the usual apathy which is so difficult to fight against was responsible for the poor attendance.

The "*Paramba*" system in Malabar, so peculiar to that district, always make a *raiyats* meeting difficult to get together. There are practically no villages in the usually accepted sense of the word. Dwellings are very scattered and one has to depend on the big landholders to get their tenants together. If the landlord is sympathetic and willing, a good number of *raiyats* can always be obtained ; if he is apathetic and takes no trouble, as sometimes happened, then it is very difficult to get at the actual cultivator.

Another factor which contributed to the difficulty of collecting audiences was the suspicion on the part of the *raiyats* that the meetings were a ruse to obtain war loan, or contribute to the war fund. Others said that, although on the face of things it was good of Government to send officers to warn them about pests and help them to save their crops they were afraid that they would be charged heavily for any demonstration or help which was given. Others again who were behindhand with their dues were afraid that they would be put to shame before their neighbours by being asked to pay on the spot at the meeting.

The magic lantern, as already stated, always proved an attraction and a cinematograph would have been better still.

The final part of the plan of the campaign could only be put to the test in one case. An exceptionally heavy monsoon which burst with great violence was apparently the cause of *S. mauritia* being in pest conditions in only one tract. In this particular case the *Adhikari* unlike the others in that *taluq* had been very slack and had taken no interest either in getting *raiyats* together or seeing that the lecturer had any assistance. However, he did notice, or the *raiyats* noticed, that the pest had arrived and sent in to *taluq* head-quarters according to the instructions received. This report reached *taluq* head-quarters on 10th June. The lecturing officer in charge of that *taluq*, although he was constantly in touch with the *taluq* office, was not told of the report until seven days later. In seven days *Spodoptera* can do a great deal of damage. In spite of these delays the pest was checked by trenching off the attacked areas and collecting the caterpillars in winnowing fans, and one-third of the seed-beds were saved. This was the only report received and all lecturers were recalled by the end of June.

The time and money spent on this campaign were not wholly wasted. The existence of the Agricultural Department was brought to the know-

ledge of a large number of the people who formerly knew nothing about it and, whether from innate courtesy or from real feeling, there were cases where gratitude was expressed that Government had taken the trouble to make all these arrangements for their benefit. One *raiyat* at least stated that he had formerly looked on Government simply as a tax-collector but had now been most happily proved to be wrong.

The Staff.

The staff used in this campaign consisted of three Assistants, three Sub-assistants from my section and two Assistant Farm Managers sent to me by the District Staff. When first drawing up the scheme for the campaign I had hoped to have a much larger number of men at my command. Things, however, turned out otherwise.

These lecturers armed with four magic lanterns actually addressed meetings of various sizes in 570 *Amsams*, or villages, taking two-and-a-half months to complete the work.

Three men had to be withdrawn as casualties on account of fever or accident. One of these was also called away for other work in another part of the Presidency and one more had to be withdrawn to head-quarters as the new term at the College was about to begin.

In conclusion, I should like to emphasize the *good results* which must follow from a campaign of this kind. Not only did it give a unique opportunity for collecting information about the distribution of various paddy pests, but it supplied the means of getting into touch with the people. Hundreds of *raiyats* who had never heard of the Agricultural Department now know of its existence, and have been given proof that Government is not merely a tax-gatherer.*

Concentration of the whole energies of the section on work on such a large scale naturally put a great strain on our resources and involved the refusal of help in many isolated cases in other parts of the Presidency. But it cannot be too strongly insisted on that once a campaign of this kind is started, it should be carried through to the end. Sickness and other casualties cannot always be avoided but men should not be withdrawn for other work. The principle of the concentration of overwhelming force at a particular point rather than the dissipation of energies against many isolated objectives should be avoided as much in pest campaigns as in war. Although we had only one opportunity of testing the final phase of the campaign and that only in the most unfavourable circumstances, I think it is justifiable to claim that, had the *Spodoptera* attack this year been as severe as it was last year and in

* This must not be construed into a criticism of the local Agricultural staff who being few in number cannot cover the whole of a big district such as Malabar.

previous years, hundreds of acres of paddy would have been saved which last year were lost.

I wish to express my gratitude to the Revenue Officials, Schoolmasters, the Publicity Bureau, and the Co-operative Societies, and especially to the Honorary Assistant Registrar and to all land-owners and village officers who gave their help.

SUMMARY OF PUBLICITY CAMPAIGN AND LESSONS LEARNT THEREFROM.

1. In all over 570 *amsams* were visited.

2. The newspaper advertisement was not attended with the success deserved by the manner in which it was done.

3. It would be better on another occasion to advertise the lectures by coloured posters and leaflets only a day or two before the lecture was given to any particular *amsam* or village.

4. A cinematograph camera would be invaluable; not only could control methods be shown actually being put into operation, but by showing one or two films of general interest large audiences could easily be collected.

5. All posting, pasting, etc., should be done by the Agricultural Department themselves and not left to Revenue Officers who already have a multiplicity of duties.

6. The present practice of distribution of leaflets, at least of those dealing with crop pests, is practically useless without lectures and, whenever possible, demonstrations at the same time.

7. Shortage of staff and the difficulty of a country like the Madras Presidency where four or five different languages are spoken makes the task of providing enough lecturers by no means easy for a campaign on such a large scale.

8. With an insect like *Spodoptera mauritia*, whose appearance at any particular spot cannot be depended on, a vary large part of the district must be covered so that all may be warned.

9. The peculiar conditions of Malabar made the collection of audiences difficult, but on the whole a good deal of interest was shown when once the lecturer began, although this naturally depended largely on the lecturer. In some cases this interest almost amounted to enthusiasm.

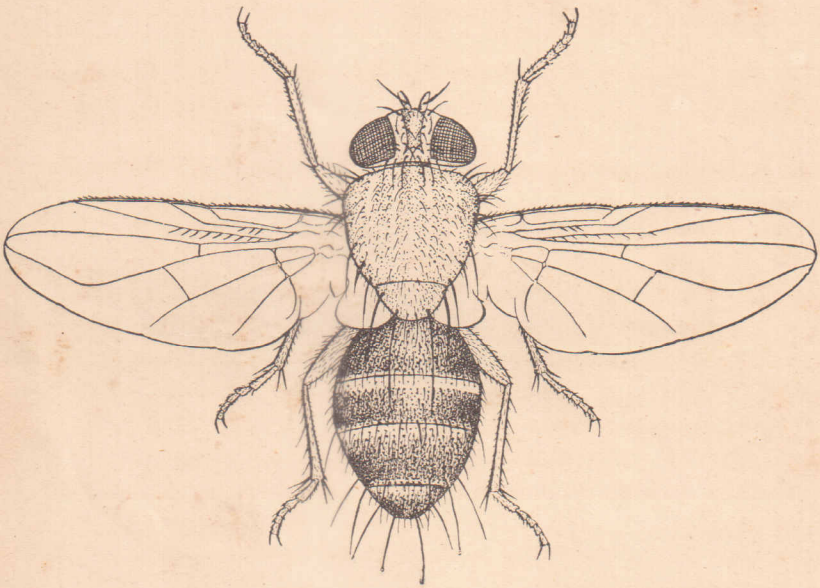
APPENDIX I.

S. mauritia is parasitized by the following Tachinidæ which have been identified by Dr. Villeneuve for the Imperial Bureau of Entomology.

1. *Actia ægyptia*, var, Villen. (Plate XI.)
2. *Pseudogonia cinerascens*, Rond. (Plate X, lower figure.)

Fig. 1.—*Cyphocera varia*, F. (×6).

Fig. 2.—*Pseudogonia cinerascens*, Rond. (×7).



Actia ægyptia, Villen (×12).

Fig. 1.—*Sturmia bimaculata*, Hartig (×10).

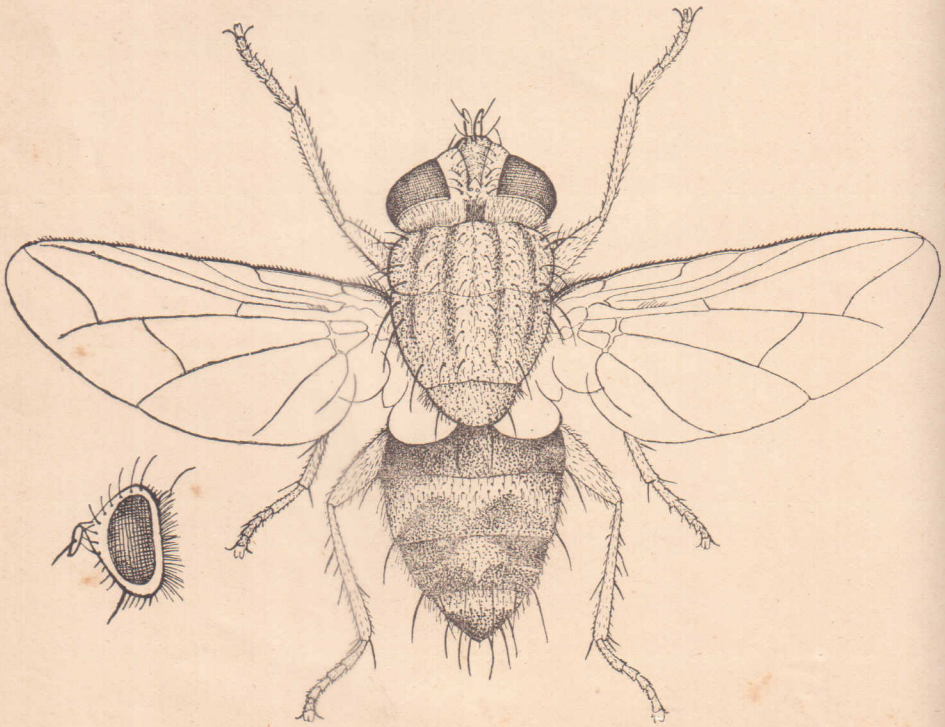


Fig. 2.—*Tachina fallax*, Meig. ♂ (×9).

3. *Tachina fallax*, Meig. (Plate XII, lower figure.)
4. *Sturmia bimaculata*, Hartig. (Plate XII, upper figure.)
5. *Cyphocera varia*, F. (Plate X, upper figure.)
6. A species of *Chelonus* (Braconidæ.)

Appendix II.

List of birds known to feed on Spodoptera mauritia.

1. Common Crow.—*Corvus splendens.*
2. Jungle crow.—*Corvus macrorhynchus.*
3. Cattle egret.—*Bubulcus coromandus.*
4. Paddy bird.—*Ardeola grayi.*
5. White-breasted water-hen.—*Amaurovius phœnicocurus.*
6. Common Mynah.—*Acridotheres tristis.*

Publications of the Imperial Department of Agriculture in India.

To be had from :—

The Office of the Agricultural Adviser to the Government of India, Pusa, Bihar, and from the following Agents :—

(1) Thacker, Spink & Co., Calcutta.
(2) W. Newman & Co., Calcutta.
(3) Rai M. C. Sarkar Bahadur & Sons, Calcutta.
(4) Higginbothams, Ltd., Madras.
(5) Thompson & Co., Madras.
(6) D. B. Taraporevala, Sons & Co., Bombay.
(7) Thacker & Co., Ltd., Bombay.
(8) Sunder Pandurang, Bombay.
(9) Rai Sahib M. Gulab Singh & Sons, Lahore
(10) Manager, Educational Book Depôt, Nagpur.

A complete list of the publications of the Imperial Department of Agriculture in India can be obtained on application from the Agricultural Adviser to the Government of India, Pusa, Bihar, or from any of the above-mentioned Agents.

These publications are :—

1. The *Agricultural Journal of India*. A Journal dealing with subjects connected with agricultural economies, field and garden crops, economic plants and fruits, soils, manures, methods of cultivation, irrigation, climatic conditions, insect pests, fungus diseases, co-operative credit, agricultural cattle, farm implements, and other agricultural matters in India. Illustrations, including coloured plates, form a prominent feature of the Journal. It is edited by the Agricultural Adviser to the Government of India, and is issued once every two months or six times a year. *Annual Subscription*, Rs. 6 or 9*s*. 6*d*., including postage. Single copy, R. 1-8 or 2*s*.
2. Scientific Reports of the Agricultural Research Institute, Pusa.
3. Annual Review of Agricultural Operations in India.
4. Proceedings of the Board of Agriculture in India.
5. Proceedings of Sectional Meetings of the Board of Agriculture.
6. Memoirs of the Imperial Department of Agriculture in India :
   (*a*) Botanical Series.
   (*b*) Chemical Series.
   (*c*) Entomological Series.
   (*d*) Bacteriological Series.
   (*e*) Veterinary Series.
7. Bulletins issued by the Agricultural Research Institute, Pusa.
8. Indigo Publications.
9. Books.

The following are the publications of the last two years :—

Scientific Reports of the Agricultural Research Institute and College, Pusa (including the Report of the Secretary, Sugar Bureau), for the year 1919-20. Price, R. 1.

Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert and the Secretary, Sugar Bureau), for the year 1920-21. Price, R. 1-8.

Review of Agricultural Operations in India, 1919-20. Price, R. 1-4.

Review of Agricultural Operations in India, 1920-21. Price, R. 1-4.

Proceedings of the Board of Agriculture in India, held at Pusa on the 13th February, 1922, and following days (with Appendices). Price, R. 1.

Proceedings of the Third Meeting of Mycological Workers in India, held at Pusa on the 7th February, 1921, and following days. Price, As. 11.

Proceedings of the Second Meeting of Agricultural Chemists and Bacteriologists, held at Pusa on the 7th February, 1921, and following days. Price, As. 10.

Proceedings of the Fourth Entomological Meeting, held at Pusa in February 1921. Price, Rs. 7-8.

MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA

Botanical Series

Vol. X, No. VI. "Kumpta" Cotton and its Improvement, by G. L. KOTTUR, B.Ag. Price, R. 1-12 or 3*s*.

Vol. XI, No. I. Some Aspects of the Indigo Industry in Bihar. Part I. The Wilt Disease of Indigo. Part II. The factors underlying the seed production and growth of Java Indigo, by ALBERT HOWARD, C.I.E., M.A., and GABRIELLE L. C. HOWARD, M.A., with the assistance of CHOWDHARY RAMDHAN SINGH and MAULVI ABDUR RAHMAN KHAN. Price, R. 1-2 or 2*s*.

Vol. XI, No. II. Studies in Diseases of the Jute Plant. (1) *Diplodia Corchori*, Syd., by F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S. Price, Rs. 2 or 2*s*. 8*d*.

Vol. XI, No. III. Morphology and Parasitism of *Acrothecium Penniseti* n. sp. (A New Disease of *Pennisetum typhoideum*), by MANORANJAN MITRA, M.Sc. Price, R. 1-4.

Vol. XI, No. IV. Studies in Gujarat Cottons, Part I, by MAGANLAL L. PATEL, B.Ag. Price, Rs. 2 or 2*s*. 6*d*

Vol. XI, No. V. Die-back of Chillies (*Capsicum* spp.) in Bihar, by JEHANGIR FARDUNJI DASTUR, M.Sc. Price, R. 1 or 1*s*. 4*d*.

Vol. XI, No. VI. The Influence of Atmospheric Conditions upon the Germination of Indian Barley, by W. YOUNGMAN, B.Sc. Price, As. 9 or 1*s*.

Vol. XI, No. VII. Correlation of Colour Characters in Rice, by G. P. HECTOR, M.A., B.Sc. Price, R. 1-4 or 1*s* 8*d*.

Vol. XI, No. VIII. The Inheritance of Characters in Rice, II, by F. R. PARNELL, M.A., Ag. DIP. (Cantab.), with the assistance of G. N. RANGASWAMI AYYANGAR, B.A., K. RAMIAH, L.Ag., and C. R. SRINIVASA AYYANGAR, L.Ag. (*In the press.*)

Chemical Series

Vol. V, Nos. VII & VIII. The Gases of Swamp Rice Soils, V—A Methane-oxidizing Bacterium from Rice Soils, by P. A. SUBRAHMANYA AYYAR, B.A., and The Gases of Swamp Rice Soils, VI—Carbon Dioxide and Hydrogen in relation to Rice Soils, by W. H. HARRISON, D.Sc. Price, As. 12 or 1*s*. 3*d*.

Vol. V, No. IX. The Retention of Soluble Phosphates in Calcareous and Non-calcareous Soils, by W. H. HARRISON, D.Sc., and SURENDRA LAL DAS, M.Sc. Price, R. 1 or 1*s*. 4*d*.

Vol. V, No. X. Windrowing Sugarcane in the North-West Frontier Province. Part I. The Effect on the Economical and Agricultural Situation, by W. ROBERTSON BROWN. Part II. The Effect on the Composition of Sugarcane, by W. H. HARRISON, D.Sc., and P. B. SANYAL, M.Sc. *Price, As. 12 or 1s.*

Vol. VI, No. I. Investigations on Indian Opium No. 1. Non-environmental Factors influencing the Alkaloidal Content and Yield of Latex from the Opium Poppy (*Papaver somniferum*), by HAROLD E. ANNETT, D.Sc. (Lond.), F.I.C., M.S.E.A.C., HARI DAS SEN, M.Sc., and HAR DAYAL SINGH, B.Sc. Price, R. 1-8 or 2*s*.

Vol. VI, No. II. Investigations on Indian Opium No. 2. The Effect of Non-environmental Factors on the Alkaloidal Content and Yield of Latex from the Opium Poppy (*Papaver somniferum*) and the bearing of the work on the functions of Alkaloids in Plant Life, by HAROLD E. ANNETT, D.Sc. (Lond.), F.I.C., M.S.E.A.C. Price, R. 2 or 2*s*. 9*d*.

Vol. VI, No. III. Studies in Soil Moisture, Part I, by B. H. WILSDON, B.A. (Oxon.), I.E.S. Price, R. 1-8 or 2*s*.

Vol. VI, Nos. IV & V. Variations in some Characteristics of the Fat of Buffalo and Cow Milk with changes in Season and Feeding; The Mutual Applicability of the Analytical Figures for Butter Fat and Ghee, by F. J. PLYMEN, A.C.G.I., and A. R. PADMANABHA AIYER, B.A. Price, As. 12 or 1*s*. 3*d*.

Entomological Series

Vol. VI, Nos. I—IX. Life-histories of Indian Insects : Microlepidoptera, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S. Price, Rs. 7-8 or 11*s.* 3*d.*

Vol. VII, Nos. I & II. New Indian Gall Midges (Diptera), by E. P. FELT ; and Description of a Rhinocyphine larva from Shillong, by Major F. C. FRASER, I.M.S. Price, As. 12.

Vol. VII, No. III. Indian Grass Gall Midges, by E. P. FELT. Price, As 10 or 1*s.*

Vol. VII, Nos. IV & V. New Indian Gall Midges (*Itonididæ*), by E. P. FELT ; Three New Wasps from India, by G. R. Dutt, B.A. Price, As. 12 or 1*s.*

Vol. VII, No. VI. Life-histories of Indian Insects. Diptera *Sphryracephala hearseiana*, Westw. by S. K. SEN, B.SC. Price, As. 12 or 1*s.*

Vol. VII, No. VII. New and Rare Indian Odonata in the Pusa Collection ; Further Notes on *Rhinocypha* Larvæ by Major F. C. FRASER, I.M.S. Price, R. 1-4 or 1*s.* 9*d.*

Bacteriological Series

Vol. I, No. VIII. Pebrine in India, by C. M. HUTCHINSON, C.I.E., B.A. Price, Rs. 3-8 or 5*s.* 6*d.*

Vol. I, No. IX. Studies on the Root Nodule Organism of the Leguminous Plants, by N. V. JOSHI, M.SC., B.A., L.Ag. Price, R. 1-4 or 2*s.* 6*d.*

Veterinary Series

Vol. III, No. II. The Virulence of Tubercle Bacilli isolated from Bovine Lesions in India, by A. L. SHEATHER, B.SC., M.R.C.V.S. Price, R. 1-4 or 1*s.* 8*d.*

Vol. III, No. III. Bovine Lymphangitis, by A. L. SHEATHER, B.SC., M.R.C.V.S. Price, R. 1-8 or 2*s.*

Vol. III, No. IV. Studies in Rinderpest, by W. A. POOL, M.R.C.V.S., and T. M. DOYLE, F.R.C.V.S. (*In the press.*)

Vol. III, No. V. Etiology of Equine Contagious Abortion in India, by T. M. DOYLE, F.R.C.V.S. (*In the press.*)

BULLETINS ISSUED BY THE AGRICULTURAL RESEARCH INSTITUTE, PUSA

No. 96. A Summary of Experiments on Rice in Bihar and Orissa from 1912 to 1919, by G. C. SHERRARD, B.A. Price, As. 10.

No. 97. *Ustilago Crameri*, Koern. on *Setaria italica*, by S. SUNDERARAMAN, M.A. Price, As. 4.

No. 98. The Course that Surra runs in Camels when Naturally Contracted and when Artificially Inoculated, by H. E. CROSS, M.R.C.V.S., D.V.H., A.SC. Price, As. 5.

No. 99. The Course that Camel Surra runs in Ponies, Buffaloes and other Animals, by H. E. CROSS, M.R.C.V.S., D.V.H., A.SC. Price, As. 4.

No. 100. Annotated List of Indian Crop-Pests, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S. Price, R. 1-8.

No. 101. Some Insects recently noted as Injurious in South India, by T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S. Price, As. 8.

No. 102. Borers in Sugarcane, Rice, etc., by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. GHOSH, B.A. Price, R. 1.

No 103. Some Indian Economic Aleyrodidæ, by C. S. MISRA, B.A. Price, As. 8.

No. 104. The Rice Leaf-hoppers, by C. S. MISRA, B.A. Price, As. 6.

No. 105. Cotton Bollworms in India, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. S. MISRA, B.A. Price, As. 8.

No. 106. The Pink Bollworm in Egypt, by LEWIS H. GOUGH, PH.D., F.E.S. Price, R. 1.

No. 107. Experiments in Egypt on the Survival of the Pink Bollworms (resting state larvæ) in Ripe Damaged Cotton Bolls buried at different depths, by F. C. WILLCOCKS. Price, As. 5.

No. 108. Some Pests of Cotton in North Bihar, by C. S. MISRA, B.A. Price, As. 6.

No. 109. *Tukra* Disease of Mulberry, by C. S. MISRA, B.A. Price, As. 4.

No. 110. The Preservation of Wood against Termites, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. GHOSH, B.A. Price, As. 3.

No. 111. Stored Grain Pests, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. GHOSH, B.A. Price, As. 14.

III. Summary

The insect pests of sugarcane in the Punjab are attacked by about 14 different kinds of parasites which have been under observation since 1921. Of these parasites the following require special mention.

Teleonomus beneficiens Zehnt. : This is a widely distributed parasite of the eggs of *Scirpophaga nivella* Fab. This parasite is most active in April and in August-October, when it parasitizes 5 and 45-68·5 per cent of the host eggs respectively.

Trichogramma spp. parasitize the eggs of *Argyria sticticraspis* Hmpsn., *Chilo zonellus* Swinh., *Sesamia uniformis* Dudgn. and *Emmalocera depressella* Swinh. These parasites are active during March-October when, in certain years, they may parasitize 90 per cent of the host eggs.

Ooencyrtus papilionus Ashm. and *Tetrastichus pyrillae* Craw. are the very important egg parasites of *Pyrilla perpusilla* Wlk. which are widely distributed in the Punjab. These parasites are most active during September-November when they may parasitize 71·5 to 79·0 per cent of the host eggs.

Other parasites are discussed under distribution, insect hosts and bionomics in this paper.

REFERENCES

Husain, M. A. (1921-38). *Ann. Repts. Ent. Govt. Punjab, Lyallpur* (for each year from 1921 to 1938)

Rahman, Khan A. and Ram Nath (1940). *Bull. Ent. Res.* (*London*) **31**, Part 2

GIPD—3 S—334 IC of AR—8-4-41—105.

BULLETINS ISSUED BY THE AGRICULTURAL RESEARCH INSTITUTE, PUSA—(*concld.*)

No. 112. Notes on Rearing Insects in Hot Climates, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., and C. C. GHOSH, B.A. Price, As. 7.

No. 113. Hints on Collecting and Preserving Insects, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S. Price, As. 10.

No. 114. The Preparation and Reproduction of Scientific Illustrations, by A. W. SLATER, Price, As. 4.

No. 115. Note on Plant Imports into India, by T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S. Price, As. 7.

No. 116. A Survey of the Indian Poppy-growing Districts for Morphine Content of the Opium produced, by H. E. ANNETT, D.Sc. (LOND.), F.I.C., M.S.E.A.C., HARI DAS SEN, M.Sc., and HAR DAYAL SINGH, B.Sc. Price, As. 2.

No. 117. Experiments with Castor Seed Conducted at Sabour, by C. SOMERS TAYLOR, B.A. Price, As. 3.

No. 118. The Saving of Irrigation Water in Wheat Growing, by ALBERT HOWARD, C.I.E., M.A., and GABRIELLE L. C. HOWARD, M.A. Price, As. 4.

No. 119. The Agricultural Development of Baluchistan, by ALBERT HOWARD, C.I.E., M.A., and GABRIELLE L. C. HOWARD, M.A. Price, As. 6.

No. 120. The Serum Simultaneous Method of Inoculation against Rinderpest, by W. A. POOL, M.R.C.V.S. Price, As. 2.

No. 121. Notes on Contagious Abortion in Pony and Donkey Mares, by R. BRANFORD, M.R.C.V.S., and T. M. DOYLE, F.R.C.V.S. Price, As. 5.

No. 122. Pusa 12 and Pusa 4 in the Central Circle of the United Provinces, by B. C. BURT, M.B.E., B.Sc., F.C.S., ALBERT HOWARD, C.I.E., M.A., and GABRIELLE L. C. HOWARD, M.A. Price, As. 11.

No. 123. The Bundelkhand Cottons. Experiments in their Improvement by Pure Line Selection, by B. C. BURT, M.B.E., B.Sc., F.C.S., and NIZAMUDDIN HAIDER. Price, As. 4.

No. 124. Safflower Oil, by ALBERT HOWARD, C.I.E., M.A., and J. STEWART REMINGTON. Price, As. 4.

No. 125. The Weevil Fauna of South India with special reference to species of Economic Importance, by T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S. Price, R. 1-4.

No. 126. Cawnpore-American Cotton, II. Further Field Trials (1918-20), Spinning Trials and Market Organization, by B. C. BURT, M.B.E., B.Sc., F.C.S. Price, As. 4.

No. 127. The Coconut Bleeding Disease, by S. SUNDERARAMAN, M.A. Price, As. 8.

No. 128. *Helminthosporium* Disease of Paddy, by S. SUNDERARAMAN, M.A. Price, As. 9.

No. 129. The Preparation of Anti-rinderpest Serum using Animals of moderate susceptibility as Virus Producers, by W. A. POOL, M.R.C.V.S., and T. M. DOYLE, F.R.C.V.S. Price, As. 12.

No. 130. Feeding Experiments at Government Cattle Farm, Hissar, by R. BRANFORD, M.R.C.V.S., and E. SEWELL, M.C., M.R.C.V.S. Price, As. 3.

No. 131. An Entomologist's Crop Pest Calendar for the Madras Presidency, by T. V. RAMAKRISHNA AYYAR, B.A., F.E.S., F.Z.S. Price, As. 2.

No. 132. Report of Campaign against *Spodoptera mauritia*, Boisd. (*Noctuidæ*) in Malabar, by E. BALLARD, B.A., F.E.S. Price, As. 2.

No. 133. Results of Investigation of Bionomics of *Platyedra gossypiella*, Saunders, in South India, together with some notes on *Earias insulana* and *E. fabia*, by E. BALLARD, B.A., F.E.S. Price, As. 5.

No. 134. Supplementary Observations on Borers in Sugarcane, Rice, etc., by C. C. GHOSH, B.A. Price, As. 6.

No. 135. Some Observations on the Control of Field Rats in the Punjab, by M. A. HUSSAIN, M.A., and HEM SINGH PRUTHI, M.Sc. Price, A. 1.

INDIGO PUBLICATIONS

No. 7. The Conditions affecting the Quality of the Java Indigo Plant (Leaf yield and richness of the leaf in indigotin), by W. A. DAVIS, B.SC., A.C.G.I. Price, As. 9.

No. 8. Note on the Development of the Indigo Industry in Assam in Conjunction with Tea and other Crops, by W. A. DAVIS, B.SC., A.C.G.I. Price, As. 3.

No. 9. The Nature of the Changes Occurring during the Extraction of Indigo from the Java Plant (*Indigofera arrecta*), by W. A. DAVIS, B.SC., A.C.G.I. Price, R. 1.

No. 10. Note on the Deterioration of Indigo Seed during Storing, by Major W. R. G. ATKINS, SC.D., F.I.C. Price, As. 3.

BOOKS

"Wheat in India," by ALBERT HOWARD, M.A., A.R.C.S., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. 288 pp. Price, Rs. 5 or 7*s.* 6*d.*

"A Description of the Imperial Bacteriological Laboratory, Muktesar: Its Work and Product," by MAJOR J. D. E. HOLMES, M.A., D.SC., M.R.C.V.S. Price, As. 8 or 9*d.*

"Agriculture in India," by JAMES MACKENNA, M.A., I.C.S. Price, As. 4 or 5*d.*

"Some Diseases of Cattle in India. A Handbook for Stock-owners." Price, As. 8 or 9*d.*

"The Importance of Bacterial Action in Indigo Manufacture," by C. M. HUTCHINSON, B.A. Price, As. 2 or 3*d.*

SGPI—M—109 AAtoGofI—18-8-22—1,000

Bulletin No. 134 19

Agricultural Research Institute, Pusa

Supplementary Observations on Borers in Sugarcane, Rice, etc.

BY

C. C. GHOSH, B.A.,

Assistant Entomologist, Burma (lately Assistant to the Imperial Entomologist)

LIBRARY
NEW DELHI

(Reprinted from the Proceedings of the Fourth Entomological Meeting)

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1922

Price, As. 6.

Edited by

The Council of the Pusa Agricultural Research Institute which is not, as a body, responsible for the opinions expressed in the Bulletin.

Bulletin No. 134 19

Agricultural Research Institute, Pusa

Supplementary Observations on Borers in Sugarcane, Rice, etc.

BY

C. C. GHOSH, B.A.,

Assistant Entomologist, Burma (lately Assistant to the Imperial Entomologist)

(Reprinted from the Proceedings of the Fourth Entomological Meeting)

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1922

Agents for the Sale of Books Published by the Superintendent of Government Printing, India, Calcutta.

IN EUROPE.

Constable & Co., 10, Orange Street, Leicester Square, London, W.C.

Kegan Paul, Trench, Trübner & Co., 68-74, Carter Lane, E.C., and 39, New Oxford Street, London, W.C.

Bernard Quaritch, 11, Grafton Street, New Bond Street, London, W.

P. S. King & Sons, 2 & 4, Great Smith Street, Westminster, London, S.W.

H. S. King & Co., 65, Cornhill, E.C., and 9, Pall Mall, W.

Grindlay & Co., 54, Parliament Street, London, S.W.

Luzac & Co., 46, Great Russell Street, London, W.C.

W. Thacker & Co., 2, Creed Lane, London, E.C.

T. Fisher Unwin, Ltd., 1, Adelphi Terrace, London, W.C.

Wheldon & Wesley, Ltd., 28, Essex Street, London, W.C.

B. H. Blackwell, 50 & 51, Broad Street, Oxford.

Deighton Bell & Co., Ltd., Cambridge.

Oliver and Boyd, Tweeddale Court, Edinburgh.

E. Ponsonby, Ltd., 116, Grafton Street, Dublin.

Ernest Leroux, 28, Rue Bonaparte, Paris.

Martinus Nijhoff, The Hague, Holland.

Otto Harrassowitz, Leipzig.

Friedländer and Sohn, Berlin.

IN INDIA AND CEYLON.

Thacker, Spink & Co., Calcutta and Simla.

Newman & Co., Calcutta.

R. Cambray & Co., Calcutta.

S. K. Lahiri & Co., Calcutta.

B. Banerjee & Co., Calcutta.

The Indian School Supply Depôt, 309, Bow Bazar Street, Calcutta, and 226, Nawabpur, Dacca.

Butterworth & Co. (India), Ltd., Calcutta.

Rai M. C. Sarcar Bahadur & Sons, 90/2A, Harrison Road, Calcutta.

The Weldon Library, 57, Park Street, West, Calcutta.

Standard Literature Co., Ltd., Calcutta.

Lall Chand & Sons, Calcutta.

Association Press, Calcutta.

Higginbotham & Co., Madras.

V. Kalyanarama Iyer & Co., Madras.

G. A. Natesan & Co., Madras.

S. Murthy & Co., Madras.

Thompson & Co., Madras.

Temple & Co., Madras.

P. R. Rama Iyer & Co., Madras.

Vas & Co., Madras.

E. M. Gopalakrishna Kone, Madura.

Thacker & Co., Ltd., Bombay.

D. B. Taraporevala, Sons & Co., Bombay.

Radhabai Atmaram Sagoon, Bombay.

Sunder Pandurang, Bombay.

Gopal Narayan & Co., Bombay.

Ram Chandra Govind & Son, Kalbadevi, Bombay.

Proprietor, New Kitabkhana, Poona.

The Standard Bookstall, Karachi.

Mangaldas Harkisandas, Surat.

Karsandas Narandas & Sons, Surat.

A. H. Wheeler & Co., Allahabad, Calcutta and Bombay.

N. B. Mathur, Supt., Nazir Kanun Hind Press, Allahabad.

Munshi Seeta Ram, Managing Proprietor, Indian Army Book Depôt, Juhi, Cawnpore.

Rai Sahib M. Gulab Singh & Sons, Mufid-i-Am Press, Lahore and Allahabad.

Rama Krishna & Sons, Lahore.

Supt., American Baptist Mission Press, Rangoon.

Proprietor, Rangoon Times Press Rangoon.

Manager, the "Hitavada," Nagpur.

S. C. Talukdar, Proprietor, Students and Company, Cooch Behar.

A. M. & J. Ferguson, Ceylon.

Manager, Educational Book Depôts, Nagpur and Jubbulpore.*

Manager of the Imperial Book Depôt, 63, Chandney Chauk Street, Delhi.*

Manager, "The Agra Medical Hall and Co-operative Association, Ltd." (Successors to A. John & Co., Agra).*

Supt., Basel Mission Book and Tract Depository, Mangalore.*

P. Varadachary & Co., Madras.*

D. C. Anand & Sons, Peshawar.*

Ram Dayal Agarwala, 184, Katra, Allahabad.*

Manager, Newal Kishore Press, Lucknow.*

Maung Lu Gale, Proprietor, Law Book Depôt, Mandalay.

* Agents for the Sale of Legislative Department publications only.

14.—SUPPLEMENTARY OBSERVATIONS ON BORERS IN SUGARCANE, RICE, ETC.

(Plates XVI—XXV.)

By C. C. Ghosh, B.A., *Assistant Entomologist, Burma (lately Assistant to the Imperial Entomologist).*

[The information contained in the following paper was collected whilst Mr. Ghosh was Insectary Assistant at Pusa, between February 1919 and September 1920, when he was transferred to Burma. The work at Pusa on Borers was initiated by me and has throughout been carried on under my close supervision and is to be considered as a part of the activities of the Entomological Section as a whole. I have, however, been too busy in other directions to be able to spare time to collaborate in writing up these notes, other than editing for press, and therefore Mr. Ghosh's name appears as sole author of this paper, which should be considered as a supplement to our former paper on this subject.—T. Bainbrigge Fletcher.]

Introductory.

Since the first paper (Borers in sugarcane, rice, etc., *Proc. Third Entl. Meeting*, February 1919) was written, a further mass of information has been collected on these very important pests. During this period there have been opportunities of getting a better idea of the external agents of damage and a more correct estimate of their activities as pests. As will appear later on, some of them are capable of doing far greater damage and that in a much shorter time than probably all the internal borers taken together. A few more internal borers also have come to light and fresh alternative food plants of several borers have been discovered. Therefore additions have been necessary to the list of borers and food plants and a change in the key for differentiating the pupæ. The order of treatment in the first paper is followed, additions being made where necessary. The key given in this paper for pupæ therefore supersedes that in the first paper. Illustrations of some of the insects included in the first paper were mislaid while the paper was going through the press and have been added in this paper. This paper, however, does not treat of the insects already dealt with in the first paper beyond giving more information in respect of some

of them, and should be considered as supplementary to the latter publication.

THE EXTERNAL AGENTS OF DAMAGE.

The external agents of damage should be grouped as follows :—

(1) Termites, commonly known as " White ants."
(2) Mole Crickets.
(3) Beetle grubs.
(4) Beetles.
(5) Red Ants (*Dorylus*).

There is hardly anything of importance to add with regard to Mole Crickets and Red Ants (*Dorylus*).

TERMITES.

With regard to termites, another year's cultivation of cane in the area in the Brickfield between the treated and untreated plots experimented upon in 1918 (see Plate 69 of First Paper) exhibited similar differences in the degree of infestation as recorded in the first paper. For the purpose of ascertaining as clearly as possible the damage by termites this plot was divided into five smaller plots. Analyses of the soils of the first of these small plots (counting from the east), which showed the least and of the fifth plot, which showed the greatest damage, exhibited slight differences in the constituents of the soils as given below. No experiments on the basis of these differences have yet been made.

	Surface soil, sugarcane Plot No. 1 showing least damage by white ants.	Surface soil, sugarcane Plot No. 5 showing greatest damage by white ants
	Per cent.	Per cent.
Sand SiO_2	53·33	53·94
Alumina Al_2O_3	5·79	3·09
Ferric Oxide Fe_2O_3	2·63	3·09
Manganese Oxide Mn_3O_4	0·032	0·05
Lime CaO	18·78	19·33
Magnesia MgO	1·00	0·86
Potash K_2O	0·37	0·53
Soda Na_2O	0·42	0·17
Phosphoric acid P_2O_5	0·08	0·08
Carbon Dioxide CO_2	15·76	16·59
Sulphuric acid SO_3	0·12	0·09
Loss on ignition	1·69	1·48
	100·00	100·00
Organic Nitrogen	0·059	0·058
Available Potash K_2O	0·0058	0·0059
Available Phosphoric acid P_2O_5	0·0002	traces.

Beetle grubs.

Beetle grubs and beetles have been grouped separately for the reason that the grubs themselves may prove to be injurious in some cases, the resultant beetles not causing any appreciable damage. Recently in 1920 there was a report of serious damage to a young maize crop in Belgaum caused by the grubs of *Phyllognathus dionysius*. Some years ago, in 1906, from the same place there was a report of similar damage to young paddy plants by the same grubs. But the beetles have not been reported to behave as pests there. On the other hand, enormous damage was done in 1919 to about 500 acres of sugarcane in the Kamrup Farm in Assam by *Alissonotum impressicolle* beetles and not by the grubs. Also such damage cannot be caused by grubs.

The grubs of the following beetles have been observed to cause damage to gramineous plants, in some cases bringing about dead-hearts exactly like the internal borers :—

Anomala bengalensis. The larva gnawed sugarcane shoots at Pusa and Dacca in the field and bored into sugarcane setts in the Insectary.

Alissonotum piceum. The larva gnawed into sugarcane shoots at Pusa in the field and bored sugarcane setts in the Insectary.

The grubs of the following have been observed to live in the soil among the roots of gramineous plants, apparently feeding on the roots, and some of them are reported to cause rather serious damage in this manner.

Autoserica insanabilis, Brenske. Larva among sugarcane, lemon, soybean and castor roots.

Apogonia proxima, Waterh. Larva among *Saccharum spontaneum* roots.

Unidentified Melolonthid (C. S. 1797). Larva among *Saccharum spontaneum* roots at Pusa.

Anomala polita, Blanch. Larva among rice and grass roots at Pusa, Muzaffarpur and Nadia, and also in leaf mould at Pusa.

Anomala varicolor, Gyll. Larva among *Saccharum spontaneum* and oat roots at Pusa.

Anomala biharensis, Arrow. Larva among sugarcane, *Saccharum spontaneum* and *Ficus* roots at Pusa.

Anomala dussumieri, Bl. Larva among sugarcane roots in the Kamrup Farm in Assam.

Adoretus versutus, Har. Larva among sugarcane and oat roots at Pusa. (Plate XVI, fig. 1.)

Adoretus caliginosus, Burm. Larva among rice, sugarcane, grass and *Saccharum spontaneum* roots at Pusa.

Alissonotum simile, Arrow. Larva among sugarcane roots at Pusa.

Pentodon bispinifrons (C. S. 768).—Larva among sugarcane roots at Pusa. (Plate XVI, fig. 2.)

Pentodon bengalense, Arr. Larva among sugarcane roots at Pusa.

Phyllognathus dionysius, Fb. Larva reported causing serious damage to young paddy and maize crops at Belgaum.

Rhyssemus germanus (C. S. 1204). Larva among *Mootha* and indigo roots at Pusa.

Rhyssemus sp. (C. S. 948). Larva among *Mootha* and cotton roots at Pusa.

Aphodius sp. (C. S. 1327 and 1350). Larva among *Mootha*, rice and cotton roots at Pusa.

Anomala sp. (C. S. 1314). Larva among *Mootha* roots at Pusa.

Tanymecus hispidus, Mshll. Larva among sugarcane roots at Pusa.

Myllocerus blandus, Fst. Larva among sugarcane and maize roots at Pusa.

Myllocerus discolor. Larva among sugarcane and maize roots at Pusa.

Myllocerus 11—pustulatus. Larva among maize and cotton roots at Pusa.

Amblyrrhinus poricollis. Larva among *Saccharum spontaneum* roots at Pusa.

A few more Curculionid grubs. Among sugarcane and maize roots.

Nodostoma subcostatum, Jac. Larva among grass roots at Pusa.

Pachnephorus impressus. Larva among maize roots at Pusa.

Monolepta signata. Larva among sugarcane roots at Pusa.

Unidentified Chrysomelid (C. S. 1640). Larva among sugarcane roots.

Formicomus caerulipennis. Larva among sugarcane roots.

Drasterius sp. (C. S. 1211). Larva among wheat roots at Pusa.

Carpophilus sp. (C. S. 1093). Larva among *Panicum* roots at Pusa.

Lordites sp. (C. S. 1089). Larva among *Panicum* sp. at Pusa.

To the above *Tipulid* and *Asilid* maggots found among grass and rice roots may be added.